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ENERGY:  
AN ANNOTATED SELECTED BIBLIOGRAPHY  
COMPILED BY SANDRA J. BLOW  
RICHARD W. PEACOCK, AND  
JOSEPH J. SHOLY  
LANGLEY RESEARCH CENTER  
TECHNICAL LIBRARY  
DECEMBER 1979



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SELECTED BIBLIOGRAPHY (NASA) 739 P  
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Pages 733, 766, 833, 1043, 1177 and 1188 are blank due to error in numbering the pages.

## PREFACE

This bibliography is an update on three previous energy bibliographies dated August 1974 (N74-27577), February 1975 (N75-27558) and July (N77-28577, N77-28578). These three bibliographies were compiled by Ms Sandra J. Blow. The completion of this bibliography was performed by Dr. Peacock and Mr. Sholy after the untimely death of Ms Blow.

This update contains approximately 7,000 selected references on energy and energy related topics from bibliographic and other sources date June 1977 through subject headings and numerous minor headings. Under each heading the entries have been arranged by the date, with the latest works first. There are some minor changes in subject headings from the previous bibliographies.

The following sources were used:

- NASA RECON - A Computerized, online interactive information system
- NASA Langley Research Center book and Document card files
- Scientific and Technical Aerospace Abstracts
- International Aerospace Abstracts
- Energy Research Abstracts
- Selected Weekly and Monthly Journals

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## GEO THERMAL -- GENERAL

BON13720# ISSUE 4 PAGE 508 CATEGORY 44 RPT#:  
NTIS/PS-79/0819/7 NTIS/PS-78/0667 NTIS/PS-77/0565  
NTIS/PS-76/0465 79/08/00 149 PAGES UNCLASSIFIED  
DOCUMENT

Supersedes NTIS/PS-78/0667; NTIS/PS-77/0565;  
NTIS/PS-76/0465

UTTL: Geothermal energy, volume 4. Citations from the  
Engineering Index data base TLSP: Progress Report,  
Aug. 1978 - Jul. 1979

AUTH: A/HUNDEMANN, A. S.

CORP: National Technical Information Service, Springfield,  
Va. AVAIL. NTIS SAP: HC \$28.00/MF \$28.00

MAJS: /\*BIBLIOGRAPHIES/\*ENERGY TECHNOLOGY/\*GEO THERMAL ENERGY  
CONVERSION/\*GEO THERMAL RESOURCES

MINS: / CORROSION/ ELECTRIC POWER PLANTS/ FRACTURING/  
GEOPHYSICS/ HEAT EXCHANGERS/ HEAT TRANSFER

ABA: GRA

ABS: Citations from worldwide literature on geothermal  
energy conversion, feasibility, development and cost  
estimates are presented. Studies on geothermal  
exploration, drilling technology, fluid flow,  
convection, thermodynamics, heat extraction, and  
electric power plants are covered. Equipment,  
corrosion, reservoir engineering, and remote sensing  
are included. This updated bibliography contains 143  
abstracts, all of which are new entries to the  
previous edition.

**N80-10881/ Idaho National Engineering Lab., Idaho Falls.  
OVERVIEW OF GEO THERMAL ENERGY IN THE UNITED  
STATES**

Robert J. Schultz and E. G. DiBello 1 May 1979 14 p refs  
Presented at the Energy Conserv. Symp., San Francisco, 1 May  
1979

(Contract EY-76-C-07-1570)

(Conf-790530-1) Avail: NTIS HC A02/MF A01

The development of hydrothermal resources, hot igneous rock  
resources, and conduction dominated resources is reviewed.  
Geothermal power generation and direct applications in the U.S.  
are discussed. DOE

BON13719# ISSUE 4 PAGE 508 CATEGORY 44 RPT#:  
NTIS/PS-79/0817/1 NTIS/PS-78/0666 NTIS/PS-77/0563  
NTIS/PS-76/0463 79/08/00 203 PAGES UNCLASSIFIED  
DOCUMENT

Supersedes NTIS/PS-78/0666; NTIS/PS-77/0563 Updates  
NTIS/PS-76/0463

UTTL: Geothermal energy. Part 3: Technology and general  
studies, volume 4. Citations from the NTIS data base  
TLSP: Progress Report, 1978 - Jun. 1979

AUTH: A/HUNDEMANN, A. S.

CORP: National Technical Information Service, Springfield,  
Va. AVAIL. NTIS SAP: HC \$28.00/MF \$28.00

MAJS: /\*BIBLIOGRAPHIES/\*GEO THERMAL ENERGY CONVERSION/\*  
TECHNOLOGY ASSESSMENT

MINS: / ELECTRIC POWER PLANTS/ GEO THERMAL RESOURCES/ HEAT  
TRANSFER/ SPACE HEATING (BUILDINGS)

ABA: GRA

ABS: Research on geothermal energy conversion, power  
plants, heat extraction, and space heating is  
reported. Studies on fluid flow, heat transfer, rock  
fracturing, computerized simulation, pressure, and  
reservoir engineering are included. Reports on  
economics, legislation, technology assessment, and  
comparative evaluation with other energy sources, are  
presented. This updated bibliography contains 195  
abstracts, all of which are new entries to the  
previous edition.

**GEO THERMAL GOES EAST, by Perer Britton.**  
Popular Science, vol. 214, no. 2, Feb. 1979, p.66-69.

The Gulf and East Coasts  
don't steam with geysers,  
but they are hot new zones  
of geothermal exploration

BON13718# ISSUE 4 PAGE 507 CATEGORY 44 RPT#:  
NTIS/PS-79/0818/9 79/08/00 329 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Geothermal energy, volume 3. Citations from the  
Engineering Index data base TLSP: Progress Report,  
May 1976 - Jul. 1978

AUTH: A/SMITH, M. F.

CORP: National Technical Information Service, Springfield,  
Va. AVAIL. NTIS SAP: HC \$28.00/MF \$28.00

MAJS: /-BIBLIOGRAPHIES/-ENERGY TECHNOLOGY/-GEOTHERMAL ENERGY  
CONVERSION

MINS: / COST ESTIMATES/ FEASIBILITY ANALYSIS/ GEOPHYSICS/  
GEOTHERMAL RESOURCES/ HEAT EXCHANGERS/ MECHANICAL  
ENGINEERING

ABA: GRA

ABS: Citations from worldwide literature on geothermal  
energy conversion, feasibility, development, and cost  
estimates are presented. Studies on geothermal  
exploration, drilling technology, fluid flow,  
convection, thermodynamics, heat extraction, and  
electric power plants are covered. Equipment,  
corrosion, reservoir engineering, and remote sensing  
are included. This updated bibliography contains 323  
abstracts, none of which are new entries to the  
previous edition.

**Pure and Applied Geophysics, 1978/79**  
**v.117, nos.1/2.**

*Power sources, Geothermal*

**GEOTHERMICS AND GEOTHERMAL ENERGY. L. Ryback and  
L. Stagen, eds. (Symposium held at Joint General  
Assembly of IASPEI & IAVCEI, Durham, England, Aug.  
11-12, 1977).**

**International Association of Seismology  
and Physics of the Earth's Interior  
International Association of Volcanology  
and Chemistry of the Earth's Interior  
Symposium on Geothermics and Aug.11-12,  
Geothermal Energy 1977**

BON14542# ISSUE 5 PAGE 623 CATEGORY 44 RPT#:  
DOE/ET-01G1 79/06/00 316 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Geothermal energy: Program summary

CORP: Department of Energy, Washington, D. C. AVAIL. NTIS  
SAP: HC A14/MF A01

MAJS: /-ENERGY POLICY/-GEOTHERMAL ENERGY CONVERSION/-PROJECT  
MANAGEMENT

MINS: / ENERGY TECHNOLOGY/ GEOTHERMAL RESOURCES/ HEAT  
EXCHANGERS/ TECHNOLOGY UTILIZATION

ABA: DOE

ABS: Descriptions of geothermal projects for the fiscal  
year 1978 are presented. Each summary gives the  
project title, contractor name, contract number,  
funding level, dates, location, and name of the  
principal investigator. Objectives and strategies for  
each program are provided.

**A79-48433 # Geothermal systems and their energy re-  
sources. D. E. White and M. Guffanti (U.S. Geological Survey, Menlo  
Park, Calif.). Reviews of Geophysics and Space Physics, vol. 17, June  
1979, p. 887-902, 497 refs.**

Geothermal systems of all types are reviewed, with particular  
reference to U.S. systems that are most likely to be utilized as energy  
sources. An evaluation of the systems leads to the conclusion that,  
although a vast quantity of thermal energy is contained in crustal  
rocks at temperatures high enough for electrical generation, depths  
are commonly too great for economic production in near future.  
Igneous-related systems with high thermal gradients are seen to  
provide attractive targets for hot dry rock technology. The feasibility  
of extracting energy directly from deep magma sources is being  
studied, but the problems appear to be formidable. V.P.

**TJ**  
**280.7**  
**.G42**  
**Geothermal energy in the Western United  
States : innovation versus monopoly /  
Sheldon L. Bierman ... [et al.] — New  
York : Praeger, 1978.  
xvii, 466 p. : ill. : 24 cm.  
Includes bibliographical references and  
index.  
ISBN 0-03-041470-9  
1. Geothermal engineering—The West.  
2. Geothermal resources—The West.  
I. Bierman, Sheldon L.**

78N32566# ISSUE 23 PAGE 3102 CATEGORY 44 RPT#:  
EPRI-ER-611-SR 78/02/00 92 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Geothermal energy prospects for the next 50 years.  
Preliminary report to the Conservation Commission  
World Energy Conference  
CORP: Electric Power Research Inst., Palo Alto, Calif.  
CSS: (Fossil Fuel and Advanced Systems Div.)  
AVAIL.NTIS SAP: HC A05/MF A01  
MAJS: /ENERGY POLICY/ GEOLOGICAL SURVEYS/ GEOTHERMAL ENERGY  
CONVERSION  
MINS: / EARTH RESOURCES/ ELECTRIC GENERATORS/ ENERGY  
TECHNOLOGY/ ENVIRONMENT EFFECTS/ GEOTHERMAL RESOURCES/  
TECHNOLOGY ASSESSMENT  
ABA: Author (ERA)  
ABS: Various facets of geothermal energy-resource base,  
electric power potential, and potential nonelectric  
uses-are considered, using information derived from  
three sources: (1) analytic computations based on  
gross geologic and geophysical features of the earth's  
crust, (2) the literature, and (3) a worldwide  
questionnaire. Discussion is presented under the  
following section headings: geothermal resources;  
electric energy conversion; nonelectric uses; recent  
international developments; environmental  
considerations, and bibliography.

78N27524# ISSUE 18 PAGE 2408 CATEGORY 44  
78/03/30 25 PAGES UNCLASSIFIED DOCUMENT

UTTL: Geothermal systems  
AUTH: A/MOHL, C.  
CORP: Jet Propulsion Lab., California Inst. of Tech.,  
Pasadena. AVAIL.NTIS SAP: HC A09/MF A01  
In its Proc. of the Alternate Energy Systems Seminar  
p 43-67 (SEE N78-27522 18-44)  
MAJS: /\*GEOTHERMAL ENERGY CONVERSION/\*GEOTHERMAL RESOURCES/  
THERMAL ENERGY  
MINS: / CALIFORNIA/ COOLING SYSTEMS/ COST ANALYSIS/ DRILLING  
/ ELASTOMERS/ WELLS  
ABA: G.Y.  
ABS: Several tasks of JPL related to geothermal energy are  
discussed. The major task is the procurement and test  
and evaluation of a helical screw drive (wellhead  
unit). A general review of geothermal energy systems  
is given. The presentation focuses attention on  
geothermal reservoirs in California, with graphs and  
charts to support the discussion. Included are  
discussions on cost analysis, systems maintenance, and  
a comparison of geothermal and conventional heating  
and cooling systems.

78N33567# ISSUE 24 PAGE 3238 CATEGORY 44 RPT#:  
TREE-1162 CNT#: EY-76-C-07-1570 78/02/00 49 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Residential space heating cost: Geothermal vs  
conventional systems  
AUTH: A/ENGEL, I. A.  
CORP: Idaho National Engineering Lab., Idaho Falls.  
AVAIL.NTIS SAP: HC A03/MF A01  
MAJS: /\*ECONOMIC ANALYSIS/\*GEOTHERMAL ENERGY CONVERSION/  
HEATING EQUIPMENT/ RESIDENTIAL AREAS  
MINS: / COST ANALYSIS/ HEAT PUMPS/ HEAT SOURCES/ THERMAL  
ENERGY  
ABA: ERA  
ABS: Operating characteristics and economics of several  
representative space heating systems are analyzed.  
Analyses are based on the use of geothermal water at  
temperatures as low as 120 F in forced air systems and  
140 F in baseboard convection and radiant floor panel  
systems. The baseboard convection system is the most  
economical type of geothermal space heating system  
when geothermal water of at least 140 F is available.  
Heat pumps utilizing water near 70 F, with negligible  
water costs, are economically feasible and they are  
particularly attractive when space cooling is included  
in system designs. Procurement and installation costs  
for similar geothermal and conventional space heating  
systems are about equal, so geothermal space heating  
is cost competitive when the unit cost of geothermal  
energy is less than or equal to the unit cost of  
conventional energy. Guides are provided for  
estimating the unit cost of geothermal energy for  
cases where a geothermal resource is known to exist.

A78-21825 Geothermal energy: its past, present and  
future contributions to the energy needs of man. H. C. H. Armistead.  
London, E. & F.N. Spon, Ltd.: New York, Halsted Press, 1978. 382  
p. 200 refs. \$27.50.

Procedures for obtaining and applying energy from geothermal  
fields are examined. Topics considered include exploration, drilling,  
bore characteristics and their measurement, fluid collection and  
transmission, electric power generation from geothermal energy,  
geothermal space heating, domestic hot water supplies, and air  
conditioning. Geothermal field geology, dual and multipurpose  
projects, the control and safety of geothermal installations, economic  
considerations, chemical and metallurgical problems, environmental  
problems, and future prospects are discussed.  
M.L.

BON13717# ISSUE 4 PAGE 507 CATEGORY 44 RPT#:  
NTIS/PS-79/0816/3 79/08/00 247 PAGES UNCLASSIFIED  
DOCUMENT

Updates NTIS/PS-76/0463

UTTL: Geothermal energy. Part 3: Technology and general studies, volume 3. Citations from the NTIS data base TLSP: Progress Report, May 1976 - Dec. 1977

AUTH: A/SMITH, M. F.

CORP: National Technical Information Service, Springfield, Va. AVAIL. NTIS SAP: MC \$28.00/MF \$28.00

MAJS: /\*BIBLIOGRAPHIES/\*ENERGY TECHNOLOGY/\*GEOTHERMAL ENERGY CONVERSION/\*GEOTHERMAL RESOURCES

MINS: / ELECTRIC POWER PLANTS/ FRACTURING/ HEAT TRANSFER/ SPACE HEATING (BUILDINGS)/ WATER HEATING

ABA: GRA

ABS: The bibliography covers Government-sponsored research on geothermal energy conversion, power plants, heat extraction, and space heating. Studies on fluid flow, heat transfer, rock fracturing, computerized simulation, pressure, and reservoir engineering are included. Reports on economics, legislation, technology assessment, comparative evaluation with other energy sources, Government policies, and planning are also cited. This updated bibliography contains 239 abstracts, none of which are new entries to the previous edition.

CORROSION CHARACTERISTICS OF MATERIALS IN  
HYPERSALINE GEOTHERMAL BRINE, by J.E. Harrar,  
R.D. McCright, and A. Goldberg.  
Sampe Quarterly, vol. 10, no. 1, October 1978,  
p. 1-15.

A flow cell (with appropriate accessories) was developed for use in short-term testing of the corrosion behavior of materials in ~100°C, hypersaline geothermal brine. An apparatus was designed to accommodate commercial (Petrolite) corrosion measurement equipment and to conduct experiments on-line at the Lawrence Livermore Laboratory Test Station in the Salton Sea Geothermal Field. The apparatus also permitted direct readings of corrosion potentials, solution redox potential ( $E_h$ ), brine flow rate, pH, and temperature. Estimates of general corrosion rates were obtained by the linear polarization resistance technique and from measurements of complete potentiodynamic polarization curves. Twenty-two alloys (with various heat treatments) were tested and readily grouped according to general corrosion resistances in acidified hypersaline (~4 M chloride) brine.

ORIGINAL PAGE IS  
OF POOR QUALITY

PROGRESS IN GEOTHERMAL ENERGY, by J. D. Garnish.  
Endeavour, vol. 2, no. 2, 1978, p. 66-71.

It would not be realistic in this brief review to attempt to offer a blow-by-blow account of the development of existing geothermal technology, nor would it be necessary. With the rapid increase in interest in geothermal topics all over the world (59 countries were represented at the last major conference on the subject) has come an increase in the literature available, and the reader who is interested in particular aspects of the subject is recommended to consult some of the references listed in the bibliography at the end of this article. A particularly good summary of the technical aspects of current geothermal energy use has been published recently by H. C. H. Armstead [1]. The aim of the present article is rather to indicate the state of the art, to outline some of the general factors which restrict the availability of geothermal energy, and then to describe in more detail two recent developments which, in the opinion of the author, have major implications for the more widespread use of heat from the Earth.

TJ Greater Los Angeles Area Energy Symposium,  
163.2 1977.  
.074 Greater Los Angeles Area Energy Symposium  
1977 ... c1977. (Card 4)  
ineers and Scientists. Proceedings series -  
Los Angeles Council of Engineers Scien-  
tists ; v. 3.

Commercial 50 MWe Geothermal Power Plants for Heber and  
Niland Type Brines

J. W. Hankin, R. A. Hogue and A. M. Rogers  
Bechtell Corporation

27

What is ERDA Doing in Geothermal?

Craig R. Cummings, Energy Programs Coordinator,  
Energy Research & Development Administration

\*

In Our Future: Geothermal Energy as Friend or Foe?

Edvard F. Wehlage, P.E., Consulting Engineer

35

Lake Bottom Thermal Gradient Survey of Three California Lakes

Dr. Roger C. Martin, State Lands Division

40

Regional Employment Implications of Geothermal Energy

James B. Pick, U.S. Riverside

159

**HEAT TRANSFER. (Special issue).**

- Power From Hot Geothermal Brines** ..... 83  
Excluding royalty expenses, this method for producing power costs around 1.67¢/kWh.
- Two-Phase Flow in Geothermal Brine Wells** ..... 87  
The trouble is that existing correlations for making flow predictions lead to a great many solutions to the same problem, and there is no way to tell which answer is best.
- Geothermal Development of the Salton Sea** ..... 89  
The minerals in these geothermal brines are worth many times the contained energy, but if this resource is to be successfully developed both minerals and energy must be recovered concurrently.

79A14726 ISSUE 3 PAGE 421 CATEGORY 44 77/00/00  
765 PAGES UNCLASSIFIED DOCUMENT DCAF A324000

UTTL: Seminar on Geothermal Energy, 1st, Brussels, Belgium,  
December 6-8, 1977. Proceedings. Volumes 1 & 2 SAP:  
PRICE OF TWO VOLUMES, \$18.75

Seminar sponsored by the Commission of the European Communities. Luxembourg. Commission of the European Communities, 1977. Vol. 1, 390 p.; vol. 2, 355 p. In English, French, and Italian. (For individual items see A79-14727 to A79-14744)

MAJS: /\*CONFERENCES/\*ENERGY TECHNOLOGY/\*GEOTHERMAL ENERGY  
CONVERSION/\*GEOTHERMAL RESOURCES

MINS: / AQUIFERS/ COMPUTER PROGRAMS/ COMPUTER TECHNIQUES/  
ENTHALPY/ EUROPE/ GEOCHEMISTRY/ GEOLOGICAL SURVEYS/  
HEATING EQUIPMENT/ HYDROGEOLOGY/ MAGNETIC SURVEYS/  
MATHEMATICAL MODELS/ POWER PLANTS/ THERMAL MAPPING/  
THERMODYNAMIC CYCLES/ WELLS

ABA: B.J.

ABS: Papers are presented on geothermal survey methods, geophysical methods of geothermal investigation, geochemistry, low enthalpy resources, and high enthalpy resources and hot dry rocks. Particular consideration is given to such topics as shallow magmatic reservoirs as a heat source of geothermal systems, geothermal surveying in France, Denmark, Netherlands, and the United Kingdom, geomagnetic anomalies in geothermal areas, optimal uses of geothermal waters for home heating in Europe, and well testing in two-phase geothermal wells.

A79-34067

Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6 - Geothermal energy and hydropower. Conference sponsored by the U.S. Department of Energy and University of Miami. Edited by T. N. Veziroglu (Miami University, Coral Gables, Fla.). Washington, D.C. Hemisphere Publishing Corp., 1978. 406 p. Price of eleven volumes, \$495. (For individual items see A79-34068 to A79-34085)

A computer optimization program for geothermal energy systems, existing geothermal space heating systems in Idaho and New Zealand, small-scale hydroelectric power plants in the northeastern U.S., and a salt gradient solar pond for heat extraction are discussed. Topics of the paper include the development of geothermal systems over an inferred upper-mantle swell, a thermogravimetric, binary-cycle loop for the exploitation of low-temperature geothermal sources, the use of geothermal resources for refrigeration, and large-span tension foils to extract energy from the sea. J.M.B.

78A27824 ISSUE 10 PAGE 1792 CATEGORY 44  
77/00/00 315 PAGES UNCLASSIFIED DOCUMENT

UTTL: Geothermal energy utilization --- Book

AUTH: A/WAHL, E. F. PAA: A/(Occidental Research Corp., La Verne, Calif.) SAP: \$12  
New York, Wiley-Interscience, 1977. 315 p.

MAJS: /\*ELECTRIC POWER PLANTS/\*ENERGY CONVERSION EFFICIENCY  
/\*ENERGY SOURCES/\*GEOTHERMAL ENERGY CONVERSION/\*  
GEOTHERMAL RESOURCES/\*MINERAL DEPOSITS

MINS: / CARBONATES/ ENERGY TECHNOLOGY/ SILICATES/ SILICON  
DIOXIDE/ SYSTEMS ENGINEERING/ THERMODYNAMIC EFFICIENCY

ABA: S.D.

ABS: The book focuses on the process technology of geothermal fluids after they reach the surface. Information on researching, designing, or evaluating process systems for producing electricity, distributing thermal energy, or recovering minerals is provided. A compilation of current knowledge about the process chemistry and thermodynamics of geothermal energy utilization is included along with a discussion of basic theories and their interpretations. Topics of interest include the chemistry of carbonates and silica as related to geothermal brine utilization, scale deposition, electrical power production using expansion machines, and thermal utilization and mineral recovery. Uses and performance of combined systems are compared.

TJ  
810  
.A79  
1977

Aspen Energy Forum, 4th, Aspen Institute for  
Humanistic Studies, 1977.  
Solar architecture : proceedings of the  
Aspen Energy Forum 1977, May 27, 28, and  
29, 1977, Aspen, Colorado / editors, Gregory  
E. Franta, Kenneth R. Olson ; graphics, T.  
Michael Manchester. -- Ann Arbor, Mich. :  
Ann Arbor Science Publishers, c1978.  
ix, 331 p. : ill. ; 24 cm.  
Includes index.

THE MEANING AND APPLICATION OF GEOTHERMAL  
ENERGY . . . . . 249  
Glenn E. Coury

A79-34072 Manmade geothermal energy. T. K. Guha, K.  
E. Davis (Subsurface, Inc., Bellaire, Tex.), R. E. Collins, J. R. Fanchi,  
and A. C. Meyers, III (Houston, University, Houston, Tex.). In:  
Alternative energy sources; Proceedings of the Miami International  
Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6.  
(A79-34067 13-44) Washington, D.C., Hemisphere Publishing Corp.,  
1978, p. 2641-2654. 14 refs, Contract No. EG-77-C-04-3974.

The injection of hot fluids into deep permeable aquifers or  
impermeable caverns may provide efficient thermal storage systems.  
In this paper, thermal losses and pumping requirements for under-  
ground storage are studied with computer simulation techniques. For  
high-temperature, high pressure storage wells, thermal losses may be  
less than one percent. Such storage wells may be feasible in 80% of  
the continental U.S. The possibility of integrating base-line electric  
power systems and geothermal storage wells used in conjunction with  
large-scale solar collector/concentrator installations is also discussed.  
J.M.B.

TJ Energy technology handbook : prepared by 142  
163.9 specialists / Douglas M. Considine, editor-  
.E54 in-chief. -- New York : McGraw-Hill, c1977.  
1874 p. in various pagings : ill. ; 24 cm.  
Includes index.  
ISBN 0-07-012430-2

#### GEOTHERMAL ENERGY TECHNOLOGY

Geothermal Energy .....	7-4
Geothermal Energy in New Zealand .....	7-14
The Geysers Geothermal Field in California .....	7-34
Geothermal Energy for Space and Process Heating .....	7-43

## GEOHERMAL - RESOURCES AND EXPLORATION

79A23280 ISSUE 8 PAGE 1430 CATEGORY 44

79/02/00 18 PAGES UNCLASSIFIED DOCUMENT

UTTL: Mining earth's heat - Hot dry rock geothermal energy  
AUTH: A/CUMMINGS, R. G.; B/MORRIS, G. E.; C/TESTER, J. W.  
D/BIVINS, R. L. PAA: D/(California, University, Los  
Alamos, N. Mex.)

Technology Review, vol. 81, Feb. 1979, p. 58-74, 78.  
Research supported by the U.S. Department of Energy.

MAJS: /\*DRY HEAT/\*EARTH CRUST/\*ELECTRIC POWER PLANTS/\*  
GEOHERMAL ENERGY CONVERSION/\*GEOHERMAL RESOURCES/\*  
IGNEOUS ROCKS

MINS: / ECONOMIC ANALYSIS/ ENERGY TECHNOLOGY/ HYDRAULIC  
EQUIPMENT/ MINING/ TEMPERATURE GRADIENTS/ THERMAL  
ENERGY/ THERMAL MAPPING

ABA: A.A.

ABS: It is estimated that energy amounting to 13,000,000  
quads are contained in crustal rock to a depth of ten  
km in the U.S. The technology of HDR (Hot Dry Rock  
Geothermal Energy) is discussed, together with an  
assessment of size and quality of HDR resource, as  
well as of extraction approaches and problems of  
containment and recovery, emphasizing variations in  
reservoir design, operating parameter values, and  
financial and regulatory criteria. A model of a  
geothermal power plant is presented, noting that the  
selection of optimum plant design conditions becomes  
more complex as reservoir temperature declines. The  
base-case parameter values used in the optimization  
model to evaluate HDR energy for production of  
electricity are given, including life of the system  
(30 years), electric plant capacity (50 MW(e)),  
maximum well flow rate (75 kg/sec), geothermal  
gradient (40 C/km), busbar price of electricity (3  
cents/kWh), and operation and maintenance costs (0.13  
cents/kWh). It is concluded that if busbar costs are  
at the high end, a considerable incentive for HDR  
development would exist.

79N32690W ISSUE 23 PAGE 3110 CATEGORY 44 RPT#

LA-UR-79-670 CONF-790815-9 CNT#: W-7405-ENG-36

79/00/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Federal hot dry rock geothermal energy development  
program: An overview

AUTH: A/NUNZ, G. J.

CORP: Los Alamos Scientific Lab., N. Mex. AVAIL: NTIS  
SAP: HC A02/MF A01

Presented at 3d US Natl. Congr. on Pressure Vessels  
and Piping, San Francisco, 25 Jun. 1979

MAJS: /\*DRY HEAT/\*ENERGY POLICY/\*GEOHERMAL ENERGY  
CONVERSION/\*GEOHERMAL RESOURCES

MINS: / ENERGY TECHNOLOGY/ NEW MEXICO/ RESERVOIRS/  
TECHNOLOGY ASSESSMENT

ABA: DOE

ABS: The formulation and evolution of the Federal hot dry  
rock geothermal energy development program were  
traced. Accomplishments to date, including the  
establishment and evaluation of the 5 MW sub t phase  
one reservoir at Fenton Hill, N.M. and various  
instrument and equipment developments, are discussed.  
Future plans presented include (1) establishment of a  
20 to 50 MW sub t phase 2 reservoir at Fenton Hill  
that will be used to demonstrate longevity and,  
eventually, electric power production and (2) the  
selection of a second site at which a direct thermal  
application will be demonstrated.

N80-10677/ National Academy of Sciences - National Research  
Council, Washington, D. C. Committee on Nuclear and Alternative  
Energy Systems.

### **GEOHERMAL RESOURCES AND TECHNOLOGY IN THE UNITED STATES**

Feb. 1979 65 p refs

(PB-298623/2: ISBN-0-309-02874-4) Avail: NTIS  
MF A01; NC National Academy of Science, Washington, D. C.,  
\$5.50 CSCL 10B

The potentials and problems of geothermal energy are  
assessed with particular focus on current obstacles in the  
development of the geothermal industry. GRA

**RENEWABLE ENERGY PROSPECTS. (Special Issue).  
(Proceedings of a Conference on Non-Fossil Fuel  
and Non-Nuclear Fuel Energy Strategies.  
Held in Honolulu, Hawaii, Jan. 9-12, 1979.  
Sponsored by the United Nations University at  
Tokyo, Japan). Wilfrid Bach, et al, eds.**

Suyama, J.: Prospects of future geothermal energy development ..... 871

**Abstract** There are three categories of geothermal resources with huge resource bases: the hydrothermal convection system, the hot igneous system, and the regional conductive environment. However, under the present technical and economic condition, high temperature hydrothermal convection is the only commercially-attractive resource for electric power generation. On the other hand, increasingly more attention is being paid to nonelectrical uses of moderate temperature geothermal resources.

National and regional research efforts should be focused initially on the assessment and development of liquid-dominated hydrothermal resources, in order to establish confidence in geothermal energy as a viable energy option at the earliest possible time. With respect to the utilization problem of liquid-dominated resources, the development of cost-effective systems to use moderate-temperature resources for both electric and nonelectric applications would greatly expand the geothermal energy potential.

Removal of the institutional uncertainties and legal barriers and encouragement by means of financial supports are necessary to stimulate the commercial activity of geothermal energy development.

**GEOHERMAL ENERGY: TECHNOLOGICAL ASPECTS OF  
EXPLOITATION**  
H. C. H. Armstead

Physics in Technology, vol. 10, no. 6, Nov. 10, 1979,  
pp. 244-251.

In an earlier article in Physics in Technology\*, Dr Haenel described the nature of thermal 'fields' and the methods used for their detection. In this sequel, we take a look at how geothermal energy, once detected, can be exploited for human needs

79A46433# ISSUE 20 PAGE 3788 CATEGORY 44  
79/06/00 16 PAGES UNCLASSIFIED DOCUMENT

UTTL: Geothermal systems and their energy resources  
AUTH: A/WHITE, D. E.; B/GUFFANTI, M. PAA: B/(U.S. Geological Survey, Menlo Park, Calif.)  
Reviews of Geophysics and Space Physics, vol. 17, June 1979, p. 887-902.

MAJS: /\*GEOHERMAL ENERGY CONVERSION/\*GEOHERMAL RESOURCES  
MINS: / CALIFORNIA/ CONDUCTIVE HEAT TRANSFER/ CONVECTIVE  
FLOW/ ENERGY TECHNOLOGY/ GEOCHEMISTRY/ GEOPHYSICS/  
GEYSERS/ HYDROGEOLOGY/ SURFACE TEMPERATURE/ WATER  
TEMPERATURE

ABA: V.P.

ABS: Geothermal systems of all types are reviewed, with particular reference to U.S. systems that are most likely to be utilized as energy sources. An evaluation of the systems leads to the conclusion that, although a vast quantity of thermal energy is contained in crustal rocks at temperatures high enough for electrical generation, depths are commonly too great for economic production in near future. Igneous-related systems with high thermal gradients are seen to provide attractive targets for hot dry rock technology. The feasibility of extracting energy directly from deep magma sources is being studied, but the problems appear to be formidable.

A80-17138 Prospects of future geothermal energy development. J. Suyama (Geological Survey of Japan, Kawasaki, Japan). (United Nations University, East-West Center, International Institute for Applied Systems Analysis, and University of Hawaii, Conference on Non-Fossil Fuel and Non-Nuclear Fuel Energy Strategies, Honolulu, Hawaii, Jan. 9-12, 1979.) Energy (UK), vol. 4, Oct. 1979, p. 871-879. 28 refs.

Prospects for the future development of the world's geothermal energy resources are analyzed. It is shown that of the three types of geothermal resources available (hydrothermal convection, hot igneous systems and regional conductive environments), only high temperature hydrothermal convection presently has the proven technology to be commercially attractive for electric power generation. Problems in the development of hydrothermal resources in Japan and the United States for electricity generation are presented, and the use of geothermal resources for nonelectrical purposes is considered. Environmental, institutional and legal aspects of the use of geothermal energy are discussed, and it is concluded that the full exploitation of potential geothermal resources requires the improvement of exploration and assessment technology, the development of appropriate technology for utilizing these resources and the removal of many institutional constraints. A.L.W.



79N32679# ISSUE 23 PAGE 3109 CATEGORY 44 RPT#:  
LA-UR-79-683 CONF-790615-12 CNT#: W-7405-ENG-36  
79/00/00 13 PAGES UNCLASSIFIED DOCUMENT

UTTL: The future of hot dry rock geothermal energy systems

AUTH: A/SMITH, M. C.

CORP: Los Alamos Scientific Lab., N. Mex. AVAIL. NTIS  
SAP: HC A02/MF A01

Presented at 3d US Natl. Congr. on Pressure Vessels  
and Piping, San Francisco, 25 Jun. 1979

MAJS: /\* DRY HEAT/ENERGY POLICY/\* GEOTHERMAL ENERGY  
CONVERSION/\* GEOTHERMAL RESOURCES

MINS: / ENERGY TECHNOLOGY/ EXTRACTION/ HEAT TRANSFER/  
TECHNOLOGY ASSESSMENT

ABA: DOE

ABS: The magnitude and distribution of hot dry rock and the  
variety of possible heat extraction techniques were  
studied. It is concluded that this energy supply can  
eventually be used on a large scale.

N80-15548# California Univ., Berkeley, Lawrence Berkeley  
Lab.

#### GEOTHERMAL ENERGY DEVELOPMENT FROM THE SALTON TROUGH TO THE HIGH CASCADES

N. E. Goldstein Jan. 1979 15 p refs Presented at the 3rd  
Natl. Conf. and Exhibition on Technol. for Energy Conserv., Tucson,  
Ariz. 23-25 Jan. 1979

(Contract W-7405-eng-48)

(LBL-8703: CONF-790107-10) Avail. NTIS  
HC A02/MF A01

Operations at Cerro Prieto, the only water-dominated  
geothermal field currently generating electric power in North  
America, were assessed to identify potential problems which  
might face U.S. producers in the Imperial Valley. Geological  
hydrogeological, geochemical, and geophysical characteristics of  
the Salton Trough were investigated, as well as those of Mt.  
Hood, Oregon, where drilling was conducted, as a preliminary  
to determining the geothermal potential of the entire Cascade  
Range. A.R.H.

#### HOT DRY ROCK: A NEW GEOTHERMAL ENERGY SOURCE,

by Jeannette J. Mortensen

Energy, vol. 3, no. 5, October 1978, p. 639-644

**Abstract**—A project being conducted by the Los Alamos Scientific Laboratory is attempting to demonstrate the technical and economic feasibility of extracting energy from the hot, dry rock geothermal resource. The system being tested is composed of two deep boreholes drilled into hot, impermeable rock and connected by a hydraulically produced fracture. In September 1977, the circulation loop was closed for the first time and water was circulated through the downhole reservoir and through a pair of 10-MW (thermal) heat exchangers. A series of long-term experiments is planned for 1978 in order to evaluate the thermal, chemical and mechanical properties of the energy extraction system.

80A19202 ISSUE 6 CATEGORY 44 78/00/00 37 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Methods for regional assessment of geothermal  
resources

AUTH: A/MUFFLER, P.; B/CATALDI, R. PAA: A/(U.S.  
Geological Survey, Menlo Park, Calif.); B/(Ente  
Nazionale per l'Energia Elettrica, Centro Ricerca  
Geotermica, Pisa, Italy)

(Ente Nazionale per l'Energia Elettrica and EPDA,  
Workshop on Geothermal Resource Assessment and  
Reservoir Engineering, Larderello, Italy, Sept. 12-16,  
1977.) Geothermics, vol. 7, no. 2-4, 1978, p. 53-89.

MAJS: /\* GEOTHERMAL ENERGY CONVERSION/\* GEOTHERMAL RE SOURCES/\*  
TECHNOLOGY ASSESSMENT

MINS: / CLASSIFICATIONS/ ECONOMIC ANALYSIS/ ELECTRIC  
GENERATORS/ ENERGY TECHNOLOGY/ GEOPOTENTIAL/ HEAT FLUX  
/ ITALY/ RECOVERABILITY/ RESERVOIRS/ TERMINOLOGY

ABA: B.U.

ABS: The paper describes the EEA-3/1 geothermal assessment  
methodology developed jointly by the United States and  
Italy. The goals of EEA-3/1 were: (1) to provide a  
comprehensive evaluation of geothermal resource  
assessment techniques in a report that can serve as a  
basis for future discussion and refinement of  
assessment methodology; (2) to propose geothermal  
resources methodology that is compatible with  
established usage in the mining and petroleum  
industries, yet takes into account the peculiar  
characteristics of geothermal energy; (3) to propose a  
methodology for forthcoming refinements and revisions  
of geothermal resource assessment in the United States  
and Italy; and (4) to stimulate the careful attention  
of geothermal resources specialists to questions of  
geothermal resources methodology, particularly with  
respect to terminology, assumptions, limitations, and  
documentation.

PROJECTING ENERGY RESOURCE UTILIZATION--THE GEOTHERMAL  
CASE, by John G. Leigh, Martin M. Scholl and Ranvir K.  
Trehan

Energy the International Journal, vol. 3, no. 4, August  
1978, p. 485-491

**Abstract**—This paper presents a simple and systematic approach to deriving energy resource-utilization projections using the geothermal resources as an example. The near-term projections are derived from considerations such as present resource development status and lead times for further development. The long-term projections are founded on experience with conceptually similar industries, size of available resources, and demands on exogenous physical resources and institutional constraints. It is suggested that such first-order analysis is valuable in the energy program-planning process.

79A41819 ISSUE 17 PAGE 3260 CATEGORY 44  
78/00/00 10 PAGES In FRENCH UNCLASSIFIED DOCUMENT  
UTT: Exploration and exploitation techniques for geothermal resources

AUTH: A/LAVIGNE, J. PAA: A/(Bureau de Recherches  
Geologiques et Minieres, Orleans, France)  
In: INOVA: Industrial innovation: Conference, Paris,  
France, June 13-17, 1977, Proceedings, Volume 2,  
(A79-41801 17-44) Paris, Ministere de l'Industrie,  
1978, p. 209-218. In French.

MAJS: /\*EXPLORATION/\*GEOTHERMAL ENERGY CONVERSION/\*  
GEOTHERMAL RESOURCES

MINS: / AQUIFERS/ COLD WATER/ ENERGY TECHNOLOGY/ FRANCE/  
HEAT TRANSFER

ABA: C.K.D.

ABS: Methods used in detecting and developing geothermal resources are reviewed. Special attention is given to low energy resources, aquifers where heat transfer is primarily by conduction and water occurs in liquid form. Geothermal installations operating in France are described briefly, and the technological characteristics of different types of deep wells are outlined. The problem of cold water reinjection is examined.

TA  
1  
I39913  
1977  
Institute of Environmental Sciences.  
Environmental technology '77: proceedings.  
— Mt. Prospect, Ill. : The Institute, cl977.  
xviii, 437 p.  
23rd annual technical meeting held in Los  
Angeles, Calif. April 25-27, 1977.  
ISBN 0-915414-17-1  
1. Environmental testing. 2.  
Environmental engineering—Societies, etc.  
I. Title.

MAKING USE OF MODERATE TEMPERATURE GEOTHERMAL RESOURCES  
By Dr. Jay F. Kunze and Susan G. Spencer . . . . .

R9 179

## PROSPECTING FOR GEOTHERMAL ENERGY BY GEOPHYSICAL METHODS.

R. Haenel.

Phys. in Technology, v.8, no.5, Sept.1977,  
p.213-218.

The list of physical techniques used in prospecting for suitable sources of geothermal energy is quite impressive: geothermics, infrared surveys, electric and electromagnetic methods, geochemical investigations, gravity, seismics . . . . They are crucial in assessing the potential for exploitation of the untapped resources underground

A80-19201 Workshop on Geothermal Resource Assessment and Reservoir Engineering, Larderello, Italy, September 12-16, 1977, Proceedings. Workshop sponsored by the Ente Nazionale per l'Energia Elettrica and ERDA. Edited by E. Barbier. *Geothermics*, vol. 7, no. 2-4, 1978, 225 p. (For individual items see A80-19202 to A80-19209)

Activity in reservoir physics and engineering and resource assessment (particularly in central and southern Tuscany) in the field of geothermal research and development is reported. Pressure transient studies made from well tests in the geologically and hydrologically complicated Travale-Radicondoli (Italy) reservoir, as well as an analysis of pressure and of decline curves in the Serrazzano reservoir are presented. In addition, the thermodynamic behavior of the Bagnore geothermal field, reservoir performance of the Geysers Field (Calif.), and an evaluation of Baltazor known geothermal resources area (Nevada), are discussed, and an estimate of the resource potential of New Zealand geothermal fields for power generation is presented. J.P.B.

A79-14726 Seminar on Geothermal Energy, 1st, Brussels, Belgium, December 6-8, 1977, Proceedings. Volumes 1 & 2. Seminar sponsored by the Commission of the European Communities, Luxembourg, Commission of the European Communities, 1977. Vol. 1, 390 p.; vol. 2, 355 p. In English, French, and Italian. Price of two volumes, \$38.75. (For individual items see A79-14727 to A79-14744)

Papers are presented on geothermal survey methods, geophysical methods of geothermal investigation, geochemistry, low enthalpy resources, and high enthalpy resources and hot dry rocks. Particular consideration is given to such topics as shallow magmatic reservoirs as a heat source of geothermal systems, geothermal surveying in France, Denmark, Netherlands, and the United Kingdom, geomagnetic anomalies in geothermal areas, optimal uses of geothermal waters for home heating in Europe, and well testing in two-phase geothermal wells. B.J.

78A32117 ISSUE 12 PAGE 2197 CATEGORY 44  
77/00/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Making use of moderate temperature geothermal resources

AUTH: A/KUNZE, J. F.; B/SPENCER, S. G. PAA: A/(Idaho National Engineering Laboratory, Idaho Falls, Idaho); B/(EG & G Idaho, Inc., Idaho)  
In: Environmental technology '77: Proceedings of the Twenty-third Annual Technical Meeting, Los Angeles, Calif., April 25-27, 1977. (A78-32101 12-31) Mount Prospect, Ill.: Institute of Environmental Sciences, 1977. p. 179-183.

MAJS: /'CLEAN ENERGY/'GEOTHERMAL ENERGY CONVERSION/'GEOTHERMAL RESOURCES/'HYDROGEOLOGY

MINS: / ENERGY TECHNOLOGY/ ENVIRONMENT EFFECTS/ IDAHO/ POWER PLANTS/ VERTICAL DISTRIBUTION

ABA: M.L.

ABS: Advantages and disadvantages of using moderate-temperature geothermal resources in comparison with high-temperature resources are examined, and research program for developing the geothermal resources of the Raft River Valley, Idaho is described. Geothermal technique improvements under study include lowering of the heat sink temperature for turbine heat, since use of organic working fluid makes very low condenser temperatures practical in the cold climate of the intermountain west; and use of concrete-asbestos pipelines in place of welded steel pipelines. Since pipeline costs are a major capital item. Also considered are the development of low-cost high-performance heat exchangers, increasing well productivity, and injection of fluids back into the reservoir.

**A78-13346** Volcanoes as a source of geothermal energy.  
W. M. Heffington, J. M. Kline, and J. W. Rottman (California, University, La Jolla, Calif.). *Energy* (UK), vol. 2, Dec. 1977, p. 457-459. 15 refs.

The thermal energy available from high-temperature magma is calculated to be  $8 \times 10$  to the 14th kcal/cu km and an upper bound for volcanic energy of  $3 \times 10$  to the 18th kcal/volcano is determined. Approximately one-third of the energy may be obtained between about 750 and 1150 C (i.e. above the solidification temperature of the magma), while the remaining two-thirds is available from magma in the solid state between ambient and around 750 C. Gas dissolved in the magma possesses about 4% of the thermal energy and a large portion of that energy is potentially available as high-temperature steam. After removal of water, the gas remaining is a low-Btu gas with a heat of combustion of about 0.3 kcal/l. Utilization of both the thermal and combustion energy is the subject of current research projects.  
(Author)

*Energy*, v.2, 1977, p.407-438.

## PROSPECTS FOR GEOTHERMAL ENERGY APPLICATIONS AND UTILIZATION IN CANADA

I. I. GLASS

Institute for Aerospace Studies, University of Toronto, Toronto, Canada

(Received 16 December 1976)

**Abstract**—Like the sun, the earth is a vast energy source. The utilization of this geothermal furnace is still in its infancy, the heat flow from the mantle to the surface ( $9 \times 10^{-2}$  cal/cm<sup>2</sup>/min; 0.063 W/m<sup>2</sup>) is the energy equivalent to  $2 \times 10^{11}$  barrels of oil per yr ( $3 \times 10^{10}$  tons or about fourfold greater than the present yearly total world energy consumption). Although today only local hot spots yielding dry and wet steam, and shallow hot-water sites are used economically, future technology may well lead to a much greater utilization. This will be done through additional imaginative and sophisticated exploitation of available regions of dry hot rock, geopressure-geothermal fields, and even deep areas of significant heat flow. Such potential utilization of geothermal resources should provide for relatively pollution-free, steam-generated electrical power, steam and hot-water for home and industry, mineral and chemical by-products, as well as numerous uses where hot water is required in agriculture, horticulture, fisheries, mining, pulp and paper and other industries. Canadian developments in these areas are still relatively dormant. The problem areas are not of a technological nature but rather of an institutional type in passing a geothermal act that would provide the incentives for exploration and economical development.

## INSTITUTIONAL AND ENVIRONMENTAL ASPECTS OF GEOTHERMAL ENERGY DEVELOPMENT, Ora R. Citron

*Nuclear Technology*, Vol. 34, no. 1, June 1977  
p. 38-42

*Until recently, the majority of work in geothermal energy development has been devoted to technical considerations of resource identification and extraction technologies. The increasing interest in exploiting the variety of geothermal resources has prompted an examination of the institutional barriers to their introduction for commercial use. A significant effort was undertaken by the Jet Propulsion Laboratory as a part of a national study to identify existing constraints to geothermal development and possible remedial actions. These aspects included legislative and legal parameters plus environmental, social, and economic considerations.*

**GEOHERMAL ENERGY DEVELOPMENT AT LLL**  
Arthur L. (Roy) Austin

Energy and Technology Review, May 1977, p.

1 - 6 The basic objective of the LLL geothermal program is to develop the advanced machinery and techniques needed for extracting energy from the hot, concentrated brines of the Salton Sea Geothermal Field in California's Imperial Valley. Geologic estimates place the capacity of this one resource at 84,000 MW-yr of electrical energy, the equivalent of a billion barrels of oil. The plan to exploit this resource calls for drilling into the reservoir, converting the heat energy of the hot brines that naturally flow up out of the drill holes into mechanical energy by turbine, and then converting this mechanical energy into electrical energy in a conventional fashion.

**TAMING GEOHERMAL BRINES FOR ELECTRICAL POWER.**  
Energy & Technology Review, July 1977, p.10-19.

Although vast sources of energy are tied up in the geothermal brine reservoirs of California's Imperial Valley, this energy cannot yet be efficiently recovered because of the massive precipitation of minerals from the brine. Precipitated solids form scale and fluid-suspended solids that can clog and erode the brine-handling machinery. The problems are most severe in the vital energy-conversion components where temperature and pressure drops are the greatest.

In parallel with engineering development of the total-flow process, we are currently investigating brine acidification as a means for controlling scale and solids precipitation. Studies are being conducted to select the component materials best suited for handling the acidified brine, and various methods are being investigated for efficient disposal of the spent brine.

TJ  
163.2  
.P4P

**Perspectives on the energy crisis : technical, regulatory, environmental, economic, prospective.** / advisory editors, Howard Gordon, Roy Meador. — Ann Arbor, Mich. : Ann Arbor Science Publishers, c1977.

2 v. : ill. : 29 cm.

**ASSESSMENT OF GEOTHERMAL RESOURCES OF THE UNITED STATES—1975** . . . . . 203

(From Geological Survey Circular 726, United States Department of the Interior)

Geothermal energies are prominent resources going to waste in many parts of the world and underutilized in others. The introduction and conclusion of this Geological Survey assessment are included here to show the directions currently being taken. Active development efforts are currently in progress. This information provides useful perspectives.

**INEL—IDAHO NATIONAL ENGINEERING LABORATORY REPORT** . . . . . 225

(Report on Advanced Energy Research Programs by the Energy Research and Development Administration)

Energy projects reported on include geothermal, test reactors, water reactor safety, and reactor waste management. This desert facility, though little known to the public, has been a major center for energy studies and breakthroughs. (Usable quantities of electricity from nuclear sources were first achieved at INEL.)

**THE POWER OF LETTING OFF STEAM**

Kenneth F. Weaver

National Geographic

Vol. 152, no. 4, October 1977,  
p. 566-579.

*Science editor Kenneth F. Weaver reports global interest and accelerating development in tapping the energy potential of our planet's subsurface heat.*

## GEOHERMAL - POLICY, REGULATION, LEASING, AND ECONOMICS

### **COST STUDY OF SUPERHEATING GEOTHERMAL STEAM.** **J. M. Hensler, and R. C. Axtman.**

**Energy, vol 4, no 3, June 1979, p. 365-371.**

**Abstract**—This study compares the electrical generating costs for hybrid plants, in which fossil fuel superheats geothermal steam, with those for conventional dry flash plants. Parameters varied in the analysis include the resource temperature and the geothermal gradient. In order to make the results generally useful, we have made conservative estimates of site dependent variables. The results indicate that superheating can significantly improve the economic competitiveness of geothermal energy and should normally be considered unconditional. In addition, superheating increases total plant output capacity and enhances thermal efficiency by 50%.

**6 articles in: ASTM Standardization News, Vol. 7, No. 10, October 1979**

- 6 Geothermal Energy and Consensus Standards—Robert R. Reeber**
- 11 The Role of Standards in Geothermal Sampling and Analysis—O. J. Vetter**
- 15 Developing Standards for Geothermal Seals—Daniel L. Hertz, Jr.**
- 19 International Developments in Geothermal Power—Ronald DiPippo**
- 29 Standardization to Accelerate the Development and Use of Geothermal Logging Instrumentation—Anthony F. Veneruso**
- 32 A Historical Perspective on Geothermal Theory: Quantification, Verification, and Cumulation—Harold Issadore Sharlin**

### **GEOHERMAL ENERGY IN IMPERIAL COUNTY, CALIFORNIA: ENVIRONMENTAL, SOCIO-ECONOMIC, DEMOGRAPHIC, AND PUBLIC OPINION RESEARCH CONCLUSIONS AND POLICY RECOMMENDATIONS.**

**Martin J. Pasqualetti.**

**Energy, vol 4, no 1, February 1979, p. 67-78.**

**Abstract**—It is estimated that thousands of megawatts of electricity could be generated from the geothermal fluids which underlie agricultural fields in Imperial County, California. Many potential environmental problems appear generally controllable. The possible inter-relationships between geothermal development and subsidence, seismicity, and water availability are, however, difficult to predict, and evaluation must await long-term, commercial-sized operations. County population will interact with energy development through employment, geographical distribution, and interaction with the larger Mexican labor pool. Exportation of the bulk of the generated electricity, however, will limit the local socio-economic impact. County residents favor geothermal development at a ratio of almost 9:1. Thirteen policy recommendations applicable to other KGRA'S in the western U.S. include: the desirability of positive public opinion, the encouragement of on-line electrical power at an early stage in the development process, the importance of determining economic-technological exploitation feasibility, and the influences of local, state, and federal regulations.

**N80-16497/** University of Southeastern Massachusetts, North Dartmouth.

#### **ECONOMICS OF GEOTHERMAL POWER**

**R. DiPippo** Feb. 1979 13 p Transl. into ENGLISH from Nucl. Elec. Power Generation (Japan), v. 26, no. 9, Sep. 1975 p. 1039-1043

(Contract EY-76-S-02-4051)

(COO-4051-43) Avail: NTIS HC A02/MF A01

Geothermal, steam, nuclear, and hydraulic construction costs, power generating costs, and utilization rate are compared. The risk factor in exploratory geothermal wells is discussed. DDE

BON14508# ISSUE 5 PAGE 619 CATEGORY 44 RPT#:  
TID-28840-DRAFT 79/00/00 98 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Commercialization strategy report for hydrothermal electric and direct heat application --- project planning of geothermal resources for geothermal energy conversion for heating electricity generation  
AUTH: A/BLACK, R. A.; B/DIONNE, J. V.; C/FALICK, L.; D/HARVEY, E. B.  
CORP: Department of Energy, Washington, D. C. AVAIL: NTIS  
SAP: HC A05/MF A01  
MAJS: /ELECTRIC GENERATORS/GEOTHERMAL ENERGY CONVERSION/GEOTHERMAL RESOURCES/HEATING/PROJECT PLANNING  
MINS: /ECONOMIC ANALYSIS/ENERGY TECHNOLOGY/HEAT TRANSMISSION/TECHNOLOGY ASSESSMENT/THERMAL ENERGY  
ABA: DOE  
ABS: The use of vapor dominated hydrothermal resources for production of electric power is discussed. The ability to handle high temperature, low to moderate-salinity geofluids and convert the heat to usable power using existing technology is reviewed. The use of high temperature, high salinity brines, and moderate temperature resources is examined for economic operation. Technical risks and environmental acceptability are discussed along with technical, market/economic, environmental, institutional readiness, and benefit analysis. A commercialization plan for hydrothermal electric and direct heat applications is presented.

79A51869 ISSUE 23 PAGE 4381 CATEGORY 44  
79/00/00 3 PAGES UNCLASSIFIED DOCUMENT

UTTL: Today's geothermal power economics and risks  
AUTH: A/LAWFORD, T. W. PAA: A/(EG&G Idaho, Inc., Idaho Falls, Idaho)  
In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979. Proceedings, Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979. p. 1034-1036.  
MAJS: /COST ESTIMATES/ECONOMIC FACTORS/FORECASTING/GEOTHERMAL ENERGY CONVERSION/GEOTHERMAL RESOURCES  
MINS: /ENERGY TECHNOLOGY/GRAPHS (CHARTS)/INDUSTRIAL MANAGEMENT/PRODUCT DEVELOPMENT  
ABA: (Author)  
ABS: Because of the infancy of the industry and of significant physical characteristics of the geothermal resources, significant variations in geothermal power costs have been quoted by different sources. This paper develops capital and power generation costs as a parameterized composite of a number of ongoing geothermal power projects, and evaluates several of the most commonly accepted 'risks' of geothermal power in terms of cost penalties to a basic cost of power. The status of geothermal power in the U.S. is also reviewed briefly.

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**880-17558/ Idaho National Engineering Lab., Idaho Falls.  
TODAY'S GEOTHERMAL POWER ECONOMICS AND RISKS**

T. W. Lawford 1979 6 p refs Presented at 14th Intersoc. Energy Conversion Conf., Boston, 5 Aug 1979  
(Contract EY-76-C-07-1570)

(CONF-790803-44) Avail: NTIS HC A02/MF A01

Capital and power generation costs are developed as a parameterized composite of a number of ongoing geothermal power projects. Several of the most commonly accepted risks of geothermal power are evaluated in terms of cost penalties to a basic cost of power. The status of geothermal power in the U.S. is reviewed.  
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**Greater Los Angeles Area Energy Symposium, Los Angeles, 1979.**

**Greater Los Angeles Area Energy Symposium  
: Tuesday, May 23, 1978 ... Los Angeles,**

• Impact of Geothermal on Requirements for Nuclear, Oil, and Coal Power Plants in California -- Richard Miller

P-108

The plans of California electric utilities to provide new sources of electric power from nuclear and coal-fired plants by 1995 are being seriously delayed. The result may be a shortage in the mid 1980's. This paper examines the exploitation of geothermal energy as an interim means of electric power generation in terms of economic and environmental viability.

proceedings ser. ; v. 4)

(Continued on card 2)

**ECONOMIC ANALYSIS OF HEAT TRANSMISSION FROM LOW TEMPERATURE GEOTHERMAL SOURCES, by Herbert E. Klei**  
Energy Conversion, vol. 18, no. 1, 1978, p. 17-23

**Abstract-** The costs of transmitting low temperature geothermal water (150-300 F) was evaluated as a function of well head temperature, distance between the geothermal field and the energy usage site, and total energy demand of the system. It was found that transmission was not practical beyond 2.3 miles and that economics of scale are very important. Energy demand should be above  $50 \times 10^6$  Btu/hr. For drying operations located within a 3 mile radius of a 270 F geothermal source, energy costs are within the \$1.50-\$3.00/10<sup>6</sup> Btu. range and could become competitive.

A78-42773 Union Oil gets up steam for geothermal energy. J. Quirt. *Fortune*, vol. 98, July 31, 1978, p. 94-96.

Union Oil has drilled almost 300 wells in the U.S. and Canada in an effort to find reliable sources of geothermal power. The capital investment has thus far been on the order of \$150 million, with an additional \$100 million foreseen in the near future. Up till now, the return has been substantially less than the original investment (between \$15-20 million), but is expected to begin yielding a profit in the mid-eighties.

79A22756 ISSUE 8 PAGE 1482 CATEGORY 83 CNT#: NSF AER-75-08793 78/11/00 27 PAGES UNCLASSIFIED DOCUMENT

UTTL: The economics of geothermal energy development at the regional level

AUTH: A/ROSE, A.; B/EDMUNDS, S.; C/LOFTING, E. PAA: C/(California, University, Riverside, Calif.)  
Journal of Energy and Development, vol. 4, Autumn 1978, p. 126-152.

MAJS: /\*ECONOMIC ANALYSIS/\*ENERGY POLICY/\*GEOTHERMAL ENERGY CONVERSION/\*REGIONAL PLANNING

MINS: / COST ANALYSIS/ GEOTHERMAL RESOURCES/ RESOURCES MANAGEMENT/ THERMAL ENERGY

ABA: A.A.

ABS: Regional economics of geothermal energy development are discussed with Imperial County, California as a case study. A multisector input-output analysis is outlined, together with the presentation of a simulated geothermal development scenario. Results of the methodology are given and interpreted, concluding that the impact of energy development on Imperial County will be significantly favorable, with the major points being employment, output and tax revenue incomes. Policies for increasing the net benefits of geothermal development are analyzed with consideration to such possible problems as appreciation of land value, environmental effects, interregional equity, and depletion of geothermal resources. It is noted that the major conclusions are not affected by alternative development scenarios within a broad technically feasible, and economically viable range.

79A34068 ISSUE 13 PAGE 2418 CATEGORY 44 78/00/00 21 PAGES UNCLASSIFIED DOCUMENT

UTTL: Harnessing geothermal energy in Rotorua, New Zealand

AUTH: A/SHANNON, R. J. PAA: A/(Ministry of Works and Development, Hamilton, New Zealand)  
In: Alternative energy sources: Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. (A79-34067 13-44)  
Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2577-2597.

MAJS: /\*ENERGY TECHNOLOGY/\*GEOTHERMAL ENERGY CONVERSION/\*NEW ZEALAND

MINS: / COST ANALYSIS/ ECONOMIC ANALYSIS/ GEOTHERMAL RESOURCES/ HEAT EXCHANGERS/ SPACE HEATING (BUILDINGS)

ABA: J.M.B.

ABS: Geothermal heat in Rotorua, New Zealand has been harnessed to provide a heat load of 1011 kW for buildings the floor area of which totals 9850 sq m. Kiln drying operations are also carried out with Rotorua geothermal resources. An economic analysis shows that capital costs of geothermalsystems are higher than investments needed for coal-fired and oil-fired plants, though operating costs are much lower than for either of the fossil-fuel installations.

78A16769 ISSUE 4 PAGE 629 CATEGORY 44 77/12/00 18 PAGES UNCLASSIFIED DOCUMENT

UTTL: Economics and projections for geothermal development in the Northwest --- Washington, Oregon and Idaho

AUTH: A/SIMMONS, G. M. PAA: A/(Idaho, University, Moscow, Idaho)  
Geothermal Energy, vol. 5, Dec. 1977, p. 8, 9, 11-13 (13 ff.). Research supported by the Pacific Northwest Regional Commission.

MAJS: /\*COST ANALYSIS/\*ECONOMIC ANALYSIS/\*GEOTHERMAL ENERGY CONVERSION/\*GEOTHERMAL RESOURCES/\*PACIFIC NORTHWEST (US)

MINS: / AGRICULTURE/ COOLING SYSTEMS/ COST INCENTIVES/ ENVIRONMENT EFFECTS/ IDAHO/ INDUSTRIAL ENERGY/ OREGON/ WASHINGTON

ABA: (Author)

ABS: The Northwestern states (Washington, Oregon, Idaho) possess a considerable potential for geothermal development. Since most of the known geothermal sources are of moderate temperature, utilization will be primarily non-electric. This paper reviews the present status of the region's geothermal development and attempts to assess the long range impact that this important energy source might have on the Northwest.

NTIS/PS-78/0664: National Technical Information Service, Springfield, Va.

**GEOTHERMAL ENERGY. PART 1: EXPLORATION. VOLUME 3. CITATIONS FROM THE NTIS DATA BASE Progress Report, May 1976 - Jun. 1979**

Audrey S. Hundemann Aug. 1979 264 p Supersedes NTIS/PS-78/0664; NTIS/PS-77/0561 Updates NTIS/PS-76/0463

(NTIS/PS-79/0814/8; NTIS/PS-78/0664; NTIS/PS-77/0561) Avail: NTIS HC \$28.00/MF \$28.00 CSCI 081

The bibliography cites Federally-funded research on geophysical methods, such as electrical resistivity, seismology, magnetic anomaly, and electromagnetic measurements in geothermal site survey determination. Studies on well logging, remote sensing, geochemistry, mineralogy, radioactivity, mapping, volcanism, and structural geology are also cited. Criteria for location of geothermal areas are suggested in these abstracts. This updated bibliography contains 256 abstracts, 81 of which are new entries to the previous edition. GRA

78A10744 ISSUE 1 PAGE 46 CATEGORY 44 CNT\*: NSF C-836 76/00/00 7 PAGES UNCLASSIFIED DOCUMENT

UTTL: Capital and electrical production costs for geothermal power plants

AUTH: A/KLEI, H. E.; B/MASLAN, F. PAA: A/(Connecticut, University, Storrs, Conn.); B/(Futures Group, Inc., Glastonbury, Conn.)

In: Energy development II. (A78-10729 01-44) New York, Institute of Electrical and Electronics Engineers, Inc., 1976, p. 148-154.

MAJS: /\*COST ANALYSIS/\*ELECTRIC POWER PLANTS/\*GEOTHERMAL ENERGY CONVERSION

MINS: / BRINES/ CLEAN ENERGY/ ENERGY TECHNOLOGY/ INVESTMENT/ STEAM/ WELLS

ABA: V.P.

ABS: In the present paper, the capital investment (composed of turbine and generator costs, exploration costs, well costs, and piping costs) for a geothermal production site are calculated. It is shown that the initial capital investment required for dry-steam geothermal plants changes little from \$180-200/KW for plants above 100 MW. When the total investment in replacement wells over 20 years is added to the initial capital investment, the total reaches a minimum for plants between 50 and 100 MW. Since the amount of flashed steam/well obtained from hot-brine wells is close to that from dry-steam wells, and their initial capital investments are the same, the above conclusions hold also for hot-brine wells. Electrical production costs are minimum for plants around 100 Mw: for a 110-MW plant, these costs are 6 to 8 mills/Kwh for both dry-steam and hot-brine systems. Hot-rock well systems are projected to have electrical costs between 4 and 8 mills/Kwh, but these costs are largely conjecture.

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**Energy development II ... c1976. (Card 2)**  
**covering papers presented at the National**  
**Power Engineering Society meetings."**  
**1. Power resources--Congresses. ?**

The Prospect for Geothermal Power, by Morton C. Smith.....

Geothermal Energy: A Challenge of Nature, by Jim Combs.....

Capital and Electrical Production Costs for Geothermal Power Plants,  
by Herbert E. Klei and Frank Maslan.....

Geothermal Energy - EPRI's Status Assessment and R&D Direction,  
by D. F. Spencer, V. W. Roberts, G. K. Underhill and L. O. Beaulaurier..



## GEOTHERMAL-- THEORY AND MODELING

78N21650W ISSUE 12 PAGE 1603 CATEGORY 44 RPT#:  
UCRL-13751 CNT#: W-7405-ENG-48 77/06/30 45 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Definition of requirements for geothermal power  
conversion system studies  
CORP: Bechtel Corp., San Francisco, Calif. AVAIL. NTIS  
SAP: HC A03/MF A01  
MAJS: /\*GEOTHERMAL ENERGY CONVERSION/\*STRUCTURAL DESIGN  
CRITERIA  
MINS: / ECONOMIC FACTORS/ ENERGY CONVERSION/ HEAT EXCHANGERS  
/ WAGE SURVEYS  
ABA: ERA  
ABS: Candidate power conversion systems and criteria for  
comparing these systems are listed. The elements of  
each conceptual design and standard approaches to  
equipment design are described. The methods used to  
calculate heat and mass balances and the data used in  
the calculations are described. The method used in  
developing the economics of each system is described  
and factors such as construction wage rates common to  
all systems are included. Standard methods for  
developing the conceptual designs and corresponding  
economics are defined so that the results of each  
system study can be readily compared to those of the  
others. The candidate conversion systems are:  
multistage flash/binary; two stage flash with  
scrubbing; total flow; multistage flash/direct contact  
(Bechtel patented process); four stage flash/binary;  
binary with direct contact heat exchangers;  
hybrid-flash/binary; hybrid-flash/total flow; and  
flash/dual cycle binary.

### FINITE-ELEMENT SOLUTIONS FOR GEOTHERMAL STEAM. J.C. Chen and J.E. Conel.

J. Energy, v.1, no.6, Nov/Dec.1977, p.364-369.

The objective of the present study is to develop the governing equations in such a manner that they can be solved by any existing conductive heat-transfer computer codes. The procedure requires an initial assumption of the temperature field and subsequent iterations to satisfy the nonlinear governing equations. The advantage of the presently proposed method is that the iterations are performed on the same discretization using an existing program. This minimizes the input for each iteration and eliminates the necessity of generating a new computer code. NASTRAN, a NASA-developed general-purpose computer code that has had wide application in the aerospace industry, is chosen to solve a sample problem.

#### A79-47256

Heat transfer in geothermal systems. P. Cheng (Hawaii, University, Honolulu, Hawaii). In: Advances in heat transfer, Volume 14, (A79-47255 21-34) New York, Academic Press, Inc., 1978, p. 1-105. 202 refs. Research supported by Stanford University; NSF Grants No. AER-72-03490-A04; No. ENG-77-272527; Contract No. E(04-3)-1093.

Theoretical and experimental investigations of convective heat transfer in geothermal systems are reviewed. The governing equations for such heat transfer in geothermal systems are examined, along with heat transfer in hot-water, water-steam two-phase, and geopressed geothermal systems. Lumped-parameter analyses for predicting averaged reservoir characteristics during production are considered, heat transfer in other geothermal systems (e.g., dry hot rock and magma) is briefly discussed, and investigations of heat transfer in geothermal wellbores are summarized. It is concluded that studies based on the idealization of a geothermal reservoir as a saturation porous medium can provide considerable insight into the physical processes involved.

F.G.M.

QC Advances in heat transfer. v. 14 / edited  
 320 by Thomas F. Irvine, Jr., James P.  
 .A1 Hartnett. -- New York : Academic Press,  
 A3 1978.

v.14 Heat Transfer in Geothermal Systems

a PING CHENG

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III. Heat Transfer in Hot-Water Geothermal Systems . . . . .	15
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78H20646# ISSUE 11 PAGE 1465 CATEGORY 44 RPT#:  
 TRFE-1164 CNT#: EY-76-C-07-1570 77/08/00 94 PAGES  
 UNCLASSIFIED DOCUMENT

UTTL: Floating power optimization studies for the cooling  
 system of a geothermal power plant

AUTH: A/SHAFFER, C. J.

CORP: Edgerton, Germeshausen and Grier, Inc., Idaho Falls,  
 Idaho. AVAIL NTIS SAP: HC A05/MF A01

MAJS: /COOLING SYSTEMS/ELECTRIC POWER PLANTS/GEOTHERMAL  
 ENERGY CONVERSION/SYSTEMS ENGINEERING

MINS: / COST EFFECTIVENESS/ HEAT EXCHANGERS/ POWER  
 EFFICIENCY

ABA: ERA

ABS: The floating power concept was studied for a  
 geothermal power plant as a method of increasing the  
 plant efficiency and decreasing the cost of geothermal  
 power. The stored cooling concept was studied as a  
 method of reducing the power fluctuations of the  
 floating power concept. Parametric and optimization  
 studies were conducted for a variety of different  
 types of cooling systems including wet and dry cooling  
 towers, direct and indirect cooling systems, forced  
 and natural draft cooling towers, and cooling ponds.  
 An indirect forced draft wet cooling tower cooling  
 system was used as a base case design for comparison  
 purposes.

## GEOTHERMAL - POWERPLANTS AND ENGINEERING

**HYBRID GEOTHERMAL-FOSSIL POWER PLANTS.** J. Kestin, R. Dipippo, and H.E. Khalifa.

Mechanical Engineering, vol 100, no 12, December 1978, p. 28-35.

The essence of the hybrid concept is to combine two sources of energy in the same conversion system so as to introduce heat into the cycle in a thermodynamically optimum manner. This means that the heat derived from a low-grade source, such as a geothermal brine, should be used for heating the working fluid at the low-temperature end of the cycle. Similarly, a high-grade energy source, such as a fossil fuel, should be made to supply heat at the highest practically admissible temperatures.

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| TK<br>2896<br>.155<br>1979 | Intersociety Energy Conversion Engineering Conference, 14th, Boston, 1979.<br>Proceedings of the 14th Intersociety Energy Conversion Engineering Conference, Boston, Massachusetts, August 5-10, 1979.<br>-- Washington, D. C. : American Chemical Society, c1979.<br>799221<br>Effect of Noncondensables on the Performance of Geothermal Steam Power Plants, H.E. Khalifa, E. Michaelides and J. Kestin .... 1029<br>799222<br>Today's Geothermal Power Economics and Risks, T.W. Lawford ..... 1034<br>799223<br>Low Temperature Geothermal Energy Use in Existing Institutional Power Plants, D. Kauffman and A.V. Houghton ..... 1037<br>799224<br>System Aspects of Geothermal Resources Utilization: The Case of Castelnuovo Val Di... |
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**HIGH TEMPERATURE ELECTRONICS FOR GEOTHERMAL ENERGY.** Anthony F. Veneruso.

IEEE Circuits and Systems, vol 1, no 3, September 1979. p. 11-17.

The worldwide production of electric power from geothermal energy sources at present is 1.2 GW. The largest facility is in the United States at The Geysers, in Northern California, where 605 MW is on-line. Recent estimates indicate that geothermal energy sources could produce over 10 GW of power in the USA by 1990; however, to achieve this goal there must be accelerated exploration and development. Developers and investors may be reluctant to make the necessary commitments if there is high risk or uncertainty in a geothermal reservoir's production potential. Also, once a system is in operation, engineers periodically need accurate and timely downhole information from each well in order to obtain optimum production. Instrumentation for geothermal borehole measurements is being expanded beyond today's limited capabilities. Prototypical logging tools have been successfully field-tested to 275°C; a high-resolution quartz pressure transducer and a gallium phosphide diode have been successfully tested. Near-term goals of current programs are to develop instrumentation for use at 275° in pressures up to 48.3 MPa (7,000 psi).

N60-12668/ Washington State Univ., Pullman. Environmental Research Center.

**COMPARISON OF GEOTHERMAL ENERGY WITH COAL OIL AND NATURAL GAS FOR SELECTED USES**

G. W. Hinman and J. Robertson 1979 102 p refs  
(Contract EY-76-S-06-2221)

(DOE/ET-27139-1: RLO/2221-T14/1) Avail: NTIS HC A08/MF A01

Environmental effects and energy efficiencies for geothermal energy, western strip-mined coal, and eastern underground mined coal applied to space heating, process heat, and electric drive were compared. The measure of an environmental effect is the amount of residual material released to the environment, and the measure of energy efficiency is the second law efficiency of the process involved. The results indicate that geothermal energy efficiencies (second law) are higher than those for coal for all three end uses. The environmental effects for geothermal supply systems are smaller than those for coal in the cases of space heat and process heat and are comparable in the case of electric drive. The optimum allocation of a finite geothermal resource and a finite coal resource between space heat and drive has been evaluated from the viewpoint of maximum end use service. The results indicate that, to the extent that location factors permit, geothermal energy should be used for space heat and coal for electric drive.

DOE

79N20508# ISSUE 11 PAGE 1448 CATEGORY 44 RPT#:  
TREE-1312 CNT#: EY-76-C-07-1570 79/01/00 80 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Measurement and control techniques in geothermal power plants

AUTH: A/WHITBECK, J. F.; B/DART, R. H.; C/MILLER, J. D.;  
D/BREWER, D. R. PAA: D/(Rogers Engineering)

CORP: Edgerton, Germeshausen and Grier, Inc., Idaho Falls,  
Idaho. AVAIL:NTIS SAP: HC A05/MF A01

MAJS: /\*CONTROL EQUIPMENT/\*ELECTRIC POWER PLANTS/\*GEOTHERMAL  
ENERGY CONVERSION/\*SYSTEMS ANALYSIS

MINS: / HARDWARE/ MEASURING INSTRUMENTS/ PILOT PLANTS/  
PRODUCTION ENGINEERING/ SYSTEMS ENGINEERING

ABA: G.Y.

ABS: The background and source material used in preparing the chapter of the Geothermal Source Book on instrumentation, measurement, and control techniques is provided. Included are detailed examples of instrumentation and control techniques currently being used in geothermal power plants. In addition, the basic guidelines and unique characteristics of instrumentation and control in geothermal systems are presented.

79N28773# ISSUE 19 PAGE 2578 CATEGORY 44 RPT#:  
LA-7603-MS CNT#: W-7405-ENG-36 79/01/00 27 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Electricity from hot dry rock geothermal energy:  
Technical and economic issues

AUTH: A/TESTER, J. W.; B/MORRIS, G. E.; C/CUMMING, R. G.;  
D/BIVINS, R. L. PAA: C/(N. Mex. Univ., Albuquerque)

CORP: Los Alamos Scientific Lab., N. Mex. AVAIL:NTIS  
SAP: HC A03/MF A01

MAJS: /\*ELECTRICITY/\*ENERGY TECHNOLOGY/\*GEOTHERMAL ENERGY  
CONVERSION/\*ROCKS

MINS: / COMPUTERIZED SIMULATION/ DRILLING/ DRY HEAT/  
ECONOMIC FACTORS

ABA: DOE

ABS: Extraction of energy from hot dry rock would make available a nearly unlimited energy source. Some of the technical problems and possible economic tradeoffs involved in a power generating system are examined and possible solutions proposed. An intertemporal optimization computer model of electricity production from a hot dry rock geothermal source has been constructed. The effects of reservoir degradation, variable fluid flow rate, and drilling operations are examined to determine optimal strategies for reservoir management and necessary conditions for economic feasibility.

BON13716# ISSUE 4 PAGE 507 CATEGORY 44 RPT#:  
NTIS/PS-79/0815/5 NTIS/PS-78/0665 NTIS/PS-77/0562  
79/08/00 165 PAGES UNCLASSIFIED DOCUMENT  
Supersedes NTIS/PS-78/0665; NTIS/PS-77/0562 Updates  
NTIS/PS-76/0463

UTTL: Geothermal energy. Part 2: Corrosion and equipment,  
volume 3. Citations from the NTIS data base TLSP:  
Progress Report, May 1976 - Jul. 1979

AUTH: A/HUNDEMANN, A. S.

CORP: National Technical Information Service, Springfield,  
Va. AVAIL:NTIS SAP: HC \$28.00/MF \$28.00

MAJS: /\*BIBLIOGRAPHIES/\*BRINES/\*CORROSION/\*GEOTHERMAL ENERGY  
CONVERSION/\*GEOTHERMAL RESOURCES

MINS: / CONCRETES/ DRILLING/ PIPES (TUBES)/ PUMPS/ STEELS

ABA: GRA

ABS: Citations of Government-sponsored research reports on corrosion and equipment studies related to geothermal energy are presented. Studies on pumps, turbines, drilling equipment, pipes, nozzles, and well casings are covered, along with studies on materials including concretes, steels and nonferrous alloys. Silica precipitation and scale formation on equipment are also cited. Performance of equipment in working fluids and brines and the chemical processes affecting performance are included. This updated bibliography contains 157 abstracts, 70 of which are new entries to the previous edition.

79N29639# ISSUE 20 PAGE 2695 CATEGORY 44 RPT#:  
C00-4051-28 CNT# EY-76-S-02-4051 78/06/00 21  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Introduction to electric energy conversion systems for  
geothermal energy resources

AUTH: A/DIPIPP0, R.

CORP: Brown Univ., Providence, R. I. CSS: (Engineering  
Div.) AVAIL: NTIS SAP: HC A02/MF A01

MAJS: /\*ENERGY TECHNOLOGY/\*GEOTHERMAL ENERGY CONVERSION/\*  
GEOTHERMAL RESOURCES

MINS: / ELECTRIC POWER PLANTS/ HEAT TRANSFER/ THERMODYNAMICS

ABA: DOE

ABS: The types of geothermal energy conversion systems in  
use are classified as follows: direct, dry steam;  
separated steam; single-flash steam; double-flash  
steam; multi-flash steam; brine/Freon binary cycle;  
and brine/isobutane binary cycle. The thermodynamics  
of each of these is discussed with reference to  
simplified flow diagrams. Typical existing power  
plants are identified for each type of system.

79A51970 ISSUE 23 PAGE 4381 CATEGORY 44  
79/00/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: Low temperature geothermal energy use in existing  
institutional power plants

AUTH: A/KAUFFMAN, D.; B/HOUGHTON, A. V. PAA: B/(New  
Mexico, University, Albuquerque, N. Mex.)  
In: Intersociety Energy Conversion Engineering  
Conference, 14th, Boston, Mass., August 5-10, 1979.  
Proceedings, Volume 1. (A79-51726 23-44) Washington,  
D.C., American Chemical Society, 1979, p. 1037-1040.  
Research supported by the New Mexico Energy and  
Minerals Department.

MAJS: /\*COST ESTIMATES/\*GEOTHERMAL ENERGY CONVERSION/\*  
SYSTEMS ENGINEERING/\*TURBOGENERATORS

MINS: / ECONOMIC FACTORS/ ENERGY TECHNOLOGY/ GRAPHS (CHARTS)  
/ TABLES (DATA)

ABA: (Author)

ABS: Preliminary system designs and economic analyses are  
presented for retrofit geothermal space heating for  
two educational institutions. For the large,  
relatively low temperature, deep reservoir in the  
Albuquerque, New Mexico, area, there is substantial  
economic incentive only for larger systems, typically  
those capable of providing 20 million Btu/hr (6000  
Kwt) or more.

## ENGINEERING ASPECTS OF GEOTHERMAL DEVELOPMENT WITH EMPHASIS ON THE IMPERIAL VALLEY OF CALIFORNIA Martin Goldsmith

Energy, Vol. 3, no. 4, April 1978 p. 127-148

**Abstract**—This review was prepared in support of a geothermal planning activity of the County of Imperial. Engineering features of potential geothermal development are outlined. Acreage requirements for drilling and powerplants are estimated, as are the costs for wells, fluid transmission pipes, and generating stations. Rough scaling relationships are developed for cost factors as a function of reservoir temperature. Estimates are made for cooling water requirements, and possible sources of cooling water are discussed. Availability and suitability of agricultural wastewater for cooling are emphasized. The utility of geothermal resources for fresh water production in the Imperial Valley is considered.

## A SCENARIO FOR GEOTHERMAL ELECTRIC POWER DEVELOPMENT IN IMPERIAL VALLEY

Donald L. Ermak

Energy, Vol. 3, no. 2, April 1978, p.203-217

**Abstract**—The growth of geothermal electric power operations in Imperial Valley, California is projected over the next 40 yr. With commercial power forecast to become available in the 1980s, the scenario considers three subsequent growth rates of 40, 100 and 250 megawatts (MW) per year. These growth rates, along with estimates of the total resource size, result in a maximum level of electric power production ranging from 1000 to 8000 MW to be attained in the 2010 to 2020 time period. Power plant siting constraints are developed and used to make siting patterns for the 400 through the 8000 MW level of power production. Two geothermal technologies are included in the scenario: flashed steam systems which can produce their own cooling water from the geothermal steam condensate and which emit noncondensable gases to the atmosphere; and high pressure, confined flow systems which inject all the geothermal fluid back into the ground. An analysis of the scenario is made with regard to well drilling and power-plant construction rates, land use, cooling water requirements, and hydrogen sulfide emissions.

N78-28772# Radian Corp., Austin, Tex.  
MATERIALS SELECTION GUIDELINES FOR GEOTHERMAL  
POWER SYSTEMS, FIRST EDITION

David W. DeBerry, Peter F. Ellis, and Colin C. Thomas Sep  
1978 319 p refs  
(Contract EG-77-C-04-3904)  
(ALO-3904-1; DCN-78-200-181-17) Avail: NTIS  
HC A14/MF A01

Nine potential power cycles are defined and diagrammed for the generation of electricity from geothermal fluids. General fluid properties that influence the applicability of power cycles to a particular geothermal resource are discussed. The corrosivity of individual process streams in power cycles is described based on variation in chemical composition and temperature. Results of materials performance tests are analyzed based on the chemical composition of the corrosive medium and physical factors such as temperature, duration of exposure, and fluid velocity. The key chemical components in geothermal fluids that are significant in determining corrosivity are identified. Both summarized and detailed results of materials performance tests in U.S. liquid-dominated resources are given. Seven U.S. liquid-dominated KGRA's are classified according to relative corrosiveness and their key chemical components are defined. The various forms and mechanisms of corrosive attack that can occur in geothermal process streams are described. The application of nonmetallic materials in geothermal environments is reported. DOE

**N80-11807/** Fluor Engineers and Constructors, Inc., Irvine, Calif.  
**HEBER GEOTHERMAL DEMONSTRATION POWER PLANT**  
 Interim Report, Aug. 1977 - Jan. 1978

Aug. 1978 87 p refs Sponsored in part by San Diego Gas and Electric Company

(EPRI Proj. 580-2)

(EPRI-ER-863; IR-1) Avail: NTIS HC A04/MF A01

The work performed from August 1977 through January 1978 pertinent to the design of the demonstration plant is reported. The Heber project objective is to design, construct and operate a power plant to produce a net power output of 45 MW/sub e/. deriving energy from a low-salinity, moderate temperature (360 F. 182 C) brine heat source available from the Heber geothermal reservoir. A binary cycle conversion system employs a light aliphatic hydrocarbon mixture to derive heat from the brine supply, through heat exchangers, and drive the turbine-generator to produce power. Power output will be distributed to California's Imperial Valley. DOE

**N78-32885/** Brown Univ., Providence, R. I. Engineering Div.

**AVAILABLE WORK IN GEOTHERMAL ENERGY**

Joseph Kestin Jul. 1978 95 p refs

(Contract EY-76-S-02-4051)

(COO-4051-25) Avail: NTIS HC A05/MF A01

The most important thermodynamic considerations needed for a clear understanding of the operation of geothermal installations used for the production of electricity are presented. A brief description is given of the nature of a geothermal reservoir and the characteristics of the most practical systems for the conversion of geothermal energy into work are described. The shortcomings of the method of cycle analysis are discussed when applied to geothermal plants. Special attention is devoted to a detailed discussion of the most important general indicators that follow for the designer from a thermodynamic analysis. Various methods of graphically interpreting the concept of available work are described in detail and the importance of easily accessible, reliable formulations of the thermophysical properties of the pure substances, solutions, and mixtures that the designer needs for success are discussed. DOE

**B0N12569#** ISSUE 3 PAGE 355 CATEGORY 44 RPT#:  
 UCID-17949 CNT#: W-7405-ENG-48 78/09/00 27 PAGES  
 UNCLASSIFIED DOCUMENT

UTTL: Hybrid staging of geothermal energy conversion processes

AUTH: A/STEIDEL, R. F.

CORP: California Univ., Livermore. Lawrence Livermore Lab.

AVAIL: NTIS SAP: HC A03/MF A01

MAJS: /GEOTHERMAL ENERGY CONVERSION/TURBINES

MINS: /ENERGY TECHNOLOGY/ SYSTEMS ENGINEERING/ WASTE ENERGY UTILIZATION

ABA: DOE

ABS: A hybrid system consists of two or more energy conversion processes. The use is examined of three energy conversion machines in hybrid systems: the conventional single-phase turbine, and the two-phase expanders known as the Lysholm engine and the radial outflow reaction turbine. Two hybrid systems are presented. The first is a two-stage, single-flash system with the Lysholm engine as the first stage, and a separator and conventional turbine as the second stage. The second system adds a radial outflow reaction turbine to recover a part of the energy rejected in the second stage. A theoretical specific power of 41.3 kW.s/lb is predicted for the two-stage, single-flash hybrid system. The addition of the radial outflow rotary turbine increases performance to 44.8 kW.s/lb. Both are superior to the double-flash system, with a specific power of 37.8 kW.s/lb. In addition, the hybrid system offers operating flexibility.

**78A29998** ISSUE 11 PAGE 2002 CATEGORY 44 CNT#:  
 EY-76-S-02-4051 78/03/00 6 PAGES UNCLASSIFIED  
 DOCUMENT

UTTL: An analysis of an early hybrid fossil-geothermal power plant proposal

AUTH: A/DIPIPPA, R.

Geothermal Energy, vol. 6, Mar. 1978, p. 31-36.

MAJS: /ELECTRIC POWER PLANTS/ENERGY CONVERSION EFFICIENCY  
 /ENERGY TECHNOLOGY/FOSSIL FUELS/GEOTHERMAL ENERGY CONVERSION

MINS: /CONDENSING/ FLASHING (VAPORIZING)/ STEAM/ STEAM TURBINES

ABA: M.L.

ABS: A thermodynamic analysis of Caufourier's proposal for a hybrid fossil-geothermal power plant (described in 1924) is presented. The proposed system would employ four stages of vapor generation by flashing followed by a fossil-fired superheater that produced both electricity and hot water. The described system would use a multiple-admission vertical-shaft axial-flow vacuum condensing turbine and four self-vaporizers which were vertical cylindrical vessels topped by a dome which housed the steam outlet and the vacuum-pump connection. Assumptions required for the analysis are discussed, and an effective efficiency of 20% for fossil-fuel utilization was found. An explanation for this value, which represents underutilization of fossil fuel, is offered.

78A40368 ISSUE 17 PAGE 3121 CATEGORY 44  
77/00/00 19 PAGES UNCLASSIFIED DOCUMENT

UTTL: The potential for geothermal and solar thermal power systems

AUTH: A/ANDERSON, J. H. PAA: A/(Sea Solar Power, Inc., York, Pa.)

In: Recent advances in engineering science; Proceedings of the Fourteenth Annual Meeting, Bethlehem, Pa., November 14-16, 1977. (A78-40301 17-31) Bethlehem, Pa., Lehigh University, 1977. p. 1297-1315.

MAJS: /\*ELECTRIC POWER PLANTS/\*ENERGY SOURCES/\*GEOTHERMAL ENERGY CONVERSION/\*OCEAN THERMAL ENERGY CONVERSION/\* SOLAR HEATING

MINS: / BY-PRODUCTS/ COOLING SYSTEMS/ DESALINIZATION/ ENERGY TECHNOLOGY/ SOLAR ENERGY CONVERSION/ TECHNOLOGICAL FORECASTING/ TURBINE ENGINES

ABA: (Author)

ABS: An approximate evaluation of potential sources of energy in the world is made. It is concluded that geothermal power, and ocean thermal power have by far the greatest potential. A comparison of cooling requirements for various thermal power plants is made. The operating principles of vapor turbine geothermal and sea thermal power plants are discussed. Sea thermal power is concluded to be, by far, our largest potential source of future energy and provides many additional products, such as fresh water, food, fuels, fertilizer, and other chemicals.

79A24240 ISSUE 8 PAGE 1436 CATEGORY 44  
78/10/00 3 PAGES UNCLASSIFIED DOCUMENT

UTTL: Soil cooling for geothermal electric power plants in the Western United States - The Raft River experiment

AUTH: A/STANLEY, N. E.; B/SLEGEL, D. L.; C/GERTSCH, W. D. PAA: C/(EG & G Idaho, Inc., Idaho National Engineering Laboratory, Idaho Falls, Idaho)

MAJS: /\*ELECTRIC POWER PLANTS/\*EVAPORATIVE COOLING/\* GEOTHERMAL ENERGY CONVERSION/\*SOILS

MINS: / COMPUTER PROGRAMS/ COOLING SYSTEMS/ CROP GROWTH/ ENERGY TECHNOLOGY/ HEAT TRANSFER/ MASS TRANSFER/ SOIL MOISTURE/ THERMAL CONDUCTIVITY/ UNITED STATES OF AMERICA

79A18099# ISSUE 5 PAGE 867 CATEGORY 44 RPT#:  
ASME PAPER 78-JPGC-PWR-18 78/09/00 10 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: History and development of condensers at the Geysers geothermal power plant

AUTH: A/FORSTER, L. L.; B/PIETRUSZKIEWICZ, J. PAA: A/(Ecolaire Condenser, Inc., Bethlehem, Pa.); B/(Pacific Gas and Electric Co., San Francisco, Calif.) SAP: MEMBERS. (ASME) \$1.50; NONMEMBERS, \$3.00

ASME, IEEE, and ASCE, Power Generation Conference, Dallas, Tex., Sept. 10-14, 1978. ASME 10 p.

MAJS: /\*CONDENSERS/\*GEOTHERMAL ENERGY CONVERSION/\* OPERATIONAL PROBLEMS/\*POWER PLANTS

MINS: / CALIFORNIA/ CLEAN ENERGY/ CORROSION RESISTANCE/ ENERGY TECHNOLOGY

ABA: M.L.

ABS: Unique environmental and materials corrosion problems affecting equipment used at the Geysers geothermal power plant are considered, and design characteristics of equipment, in particular of condensers, used at each of the 15 Geysers generating units are described. The power plant cycle used with direct contact condensers and the cycle used with surface condensers are reported. Improvements in condenser design and in the design of associated noncondensable gas-removal systems are surveyed.

79A38947# ISSUE 16 PAGE 3032 CATEGORY 44  
78/12/00 23 PAGES UNCLASSIFIED DOCUMENT DCAF  
A010632

UTTL: Thermodynamic considerations for the energy conversion process in geothermal power plants

AUTH: A/NISHIKAWA, K.; B/YOSHIDA, S.; C/MORI, H. PAA: B/(Kyushu University, Fukuoka, Japan) Kyushu University, Faculty of Engineering, Memoirs, vol. 38, Dec. 1978, p. 327-349.

MAJS: /\*ELECTRIC POWER PLANTS/\*GEOTHERMAL ENERGY CONVERSION /\*SYSTEM EFFECTIVENESS/\*THERMODYNAMIC EFFICIENCY/\* THERMODYNAMIC PROPERTIES

MINS: / COST EFFECTIVENESS/ ECONOMIC ANALYSIS/ ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY

ABA: S.D.

ABS: The utilization factor of energy in a geothermal power plant is considered. For a geothermal power plant, the thermal efficiency does not act as an immediate criterion of economics, because the energy input to this plant is a geothermal fluid free of cost. It is proposed to adopt effectiveness as the utilization factor. Effectiveness is based on the concept of availability, applicable to quantitative assessment of energy according to the second law of thermodynamics. Information derived from some examples of energy and availability accounting for existing geothermal power plants with flashing system is discussed. Based on the effectiveness of geothermal power plants, the optimum flashing pressure is analytically examined.

79A15920 ISSUE 4 PAGE 648 CATEGORY 44 CNTR:  
EY-76-S-02-4051 78/00/00 11 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Hybrid fossil-geothermal power plants

AUTH: A/KHALIFA, H. E.; B/DIPIPO, R.; C/KESTIN, J. PAA:  
C/(Brown University, Providence, R.I.)  
In: Energy technology V: Challenges to technology:  
Proceedings of the Fifth Conference, Washington, D.C.,  
February 27-March 1, 1978. (A79-15879 04-44)  
Washington, D.C., Government Institutes, Inc., 1978,  
p. 960-970.

MAJS: /\*ELECTRIC POWER PLANTS/\*ENERGY CONVERSION EFFICIENCY  
/\*FOSSIL FUELS/\*GEOTHERMAL ENERGY CONVERSION

MINS: / BINARY FLUIDS/ ENERGY TECHNOLOGY/ FIGURE OF MERIT/  
RANKINE CYCLE

ABA: (Author)

ABS: The concept of hybrid utilization of fossil and  
geothermal energy is discussed. The concept is applied  
to two types of plant: the geothermal-preheat hybrid  
and the fossil-superheat hybrid. In the first, the  
geothermal fluid is used for preheating the feedwater  
in a Rankine steam power cycle; in the second, steam  
produced by flashing a geothermal fluid is superheated  
in a fossil-fired superheater. Results are given for a  
typical case of a geofluid at 200 C. and show that a  
geothermal-preheat hybrid plant can produce 4% more  
work than could be obtained from using the fossil fuel  
in a state-of-the-art power plant, or 60% more work  
than a state-of-the-art geothermal plant could yield,  
for the same input. For the fossil-superheat hybrid  
plant, the corresponding figures are 26% for fossil  
usage and 8% for geothermal usage.

79A15880 ISSUE 4 PAGE 644 CATEGORY 44 78/00/00  
13 PAGES UNCLASSIFIED DOCUMENT

UTTL: Geothermal energy from a utility perspective ---  
Imperial Valley of Southern California

AUTH: A/COLSTON, B. W. PAA: A/(San Diego Gas and Electric  
Co., San Diego, Calif.)

In: Energy technology V. Challenges to technology:  
Proceedings of the Fifth Conference, Washington, D.C.,  
February 27-March 1, 1978. (A79-15879 04-44)  
Washington, D.C., Government Institutes, Inc., 1978,  
p. 48-60.

ABA: (Author)

ABS: This paper discusses geothermal energy from a utility  
perspective with emphasis on systems using  
liquid-dominated resources. The status of development  
for geothermal energy in the United States and other  
countries is described, including a discussion of  
development programs of appropriate organizations such  
as the Department of Energy and the Electric Power  
Research Institute. The geothermal program of San  
Diego Gas and Electric Company is covered,  
highlighting the Niland Geothermal Loop Experimental  
Facility and the proposed Heber Geothermal  
Demonstration Plant. Further, development of  
geothermal resources in the Imperial Valley of  
southern California is outlined. Next, the problems,  
risks and uncertainties associated with commercial  
geothermal power plants are addressed. Lastly, the  
economic aspects of geothermal systems are summarized.

79A32591 ISSUE 13 PAGE 2403 CATEGORY 44  
78/10/00 16 PAGES UNCLASSIFIED DOCUMENT DCAF  
A004161

UTTL: MHI's recent achievements in the field of geothermal  
power generation

AUTH: A/AIKAWA, K.; B/FUKUDA, S.; C/TAHARA, M. PAA:  
C/(Mitsubishi Heavy Industries, Ltd.; Nagasaki  
Shipyard and Engine Works, Nagasaki, Japan)  
Mitsubishi Heavy Industries Technical Review, vol. 15,  
Oct. 1978, p. 195-207.

MAJS: /\*ELECTRIC POWER PLANTS/\*ENERGY TECHNOLOGY/\*FLASHING  
(VAPORIZING)/\*GEOTHERMAL ENERGY CONVERSION/\*STEAM  
TURBINES/\*TURBOGENERATORS

MINS: / AXIAL FLOW TURBINES/ BINARY FLUIDS/ CONDENSERS  
(LIQUIFIERS)/ GRAPHS (CHARTS)/ PIPELINES/ STEAM FLOW/  
THERMODYNAMIC EFFICIENCY/ TURBOMACHINERY/ WELLS

ABA: P.T.H.

ABS: The paper gives the technical data on about fifteen  
geothermal power stations throughout the world, and  
then goes into some more detail on some recently  
installed plants. Some of these are of the single  
flash type, where the steam-water mixture from the  
geothermal wells is led to a well head separator, and  
the separated steam is fed to a turbine for power  
generation. The Hatchobaru plant features a double  
flash cycle, in which the hot water from the separator  
is led to a second flasher at reduced pressure, so the  
water is flashed. The resulting secondary steam is fed  
to an intermediate stage of the turbine to increase  
the output. A schematic diagram of the double flash  
cycle plant is presented. The Hatchobaru plant also  
features a unique steam-water mixture transmission  
system. Only one transmission pipeline is required  
between each well and the plant. The geothermal double  
flash cycle power plant with two-phase flow  
transmission is producing 15-25% higher power  
generation than in the single flash cycle. Total  
investment cost is 5% higher than for the single flash  
cycle, but power generating cost is 10-20% lower.



AICHE Symposium Series, v.74,  
no.174.

1978

HEAT TRANSFER: RESEARCH AND APPLICATION. John C.  
Chen, ed. (Papers presented at 15th National  
Heat Transfer Conf., San Francisco, Calif.,  
Aug.1975).

American Institute of Chemical  
Engineers  
National Conference on Heat  
Transfer

Aug.  
1975

# HEAT EXCHANGER TESTS WITH MODERATELY SALINE GEOTHERMAL BRINE

G. L. Lombard

Small scale tube-in-shell heat exchangers were operated in the Imperial Valley  
near Heber, California, with geothermal brine containing 14 500 ppm dissolved  
solids and having a pH of 6.2. Scale deposits were experienced on tube surfaces  
exposed to the brine during the experiment, which caused the overall heat trans-  
fer coefficient to decrease linearly with operating time.

The time rate of decline in heat transfer performance increases as the brine  
was cooled from 350° to 150° F. Scale deposition, indicated by the heat transfer  
coefficient, is a strong function of the brine temperature level and brine velocity.  
Brine-side pressure loss in the heat exchanger test unit was not significantly  
affected by the thin, uniform scale layer observed on tube surfaces exposed to  
geothermal brine. Chemical cleaning effectively removed the scale layer devel-  
oped on tube surfaces after continuous exposure to the geothermal brine for 560  
hr. Corrosion of the titanium tubes was not observed after the completion of the  
tests.

## A GEOTHERMAL ENERGY PLANT.

J.S. Wilson.  
CEP Chem. Eng. Progress, v.73, no.11, Nov.1977,  
p.95-98.

In order for geopressured, geothermal reservoirs to  
be economical sources of electric power their waters  
must contain large volumes of methane, and temperature  
must be above 300° F.

79A19778# ISSUE 6 PAGE 1027 CATEGORY 44 RPT#:  
ASME PAPER 78-WA/ENER-7 78/12/00 10 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Geothermal power and water production studies at the  
University of California

AUTH: A/LAIRD, A. D. K.; B/TLEIMAT, B. W.; C/DARNELL, J.  
R.; D/SMITH, G. J.; E/STICKEL, F. V. PAA:  
B/(California, University, Berkeley, Calif.);  
C/(Bechtel National, Inc., San Francisco, Calif.);  
D/(Exxon Research and Engineering Co., Florham Park,  
N.J.); E/(United Technologies Corp., Chemical Systems  
Div., Sunnyvale, Calif.) SAP: MEMBERS, \$1.50;  
NONMEMBERS, \$3.00

American Society of Mechanical Engineers, Winter  
Annual Meeting, San Francisco, Calif., Dec. 10-15,  
1978. 10 p.

MAJS: /\*GEOTHERMAL ENERGY CONVERSION/\*THERMOHYDRAULICS/\*  
WATER TEMPERATURE/\*WORKING FLUIDS

281 MINS: / CARBONATES/ ENERGY TECHNOLOGY/ THERMODYNAMIC CYCLES  
ABA: (Author)

ABS: This paper summarizes results of studies on geothermal  
dual-purpose power and water production plants using  
geothermal and other working fluids. Combinations of  
heat exchanger and direct contact condensers with  
evaporative, dry and mixed cooling are considered.  
Effects of system parameters on production are given.  
Higher temperatures favor the use of open, or water,  
cycles, particularly when brines are low in dissolved  
solids, noxious gases and bicarbonates. At lower  
temperatures, either the water or the binary fluid  
cycle may be preferable, depending on conditions.

TK  
2896  
.155  
1977

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Intersociety Energy Conversion Engineering  
Conference, 12th, Washington, 1977.  
Proceedings ...c1977

Geothermal Power Systems I—Heat Transfer in  
Geothermal Systems p. 798 - 831. es.

Geothermal Power Systems II—Power Cycle and  
Working Fluid Evaluations p. 832 - 876

Geothermal Power Systems III—Geothermal Power  
Cycle Components p. 877 - 912.

Using Salton Sea Geothermal Brines for Electrical  
Power, G. E. Tardiff, University of California,  
Livermore ..... 1723

ORIGINAL PAGE IS  
OF POOR QUALITY

BON15615# ISSUE 6 PAGE 765 CATEGORY 44 RPT#:  
CONF-751270-SUMM 78/10/00 138 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: All-union scientific and technical conference on use  
of the earth's heat for the production of electric  
power - summary of reports  
CORP: Department of Energy, Washington, D. C. AVAIL:NTIS  
SAP: HC A07/MF A01  
Conf. held at Moscow, 10-14 Dec. 1975 Transl. into  
ENGLISH of Vsesoyuznoye Nauchno-Tekhnicheskoye  
Soveshchaniye. Ispol'zovaniye tepla zemli dlya  
Proizvodstva Elektroenergii (Izisy Doklady). USSR  
Ministry of Power and Electrification, 1975 186 p  
MAJS: /-CONFERENCES/-ENERGY TECHNOLOGY/-GEOTHERMAL ENERGY  
CONVERSION/-GEOTHERMAL RESOURCES  
MINS: / ELECTRIC POWER TRANSMISSION/ ELECTRICITY/ GEOPHYSICS  
/ HEAT TRANSFER/ THERMOELECTRIC POWER GENERATION  
ABA: A.W.H.  
ABS: The use and effectiveness of geothermal energy for  
producing electric power is discussed. Topics include  
the operation of geothermal electric stations and  
power plants, systems for the extraction of heat from  
the Earth's crust, drilling of geological prospecting  
boreholes for steam, and geophysical methods for  
monitoring the parameters of underground heat boilers.

## ENERGY CONVERSION ENGINEERING Anders W. Lundberg

Energy and Technology Review, May 1977, p. 7 -  
16

Efficiently extracting energy from the hot,  
corrosive brines of the Salton Trough presents  
problems that rule out all conventional turbines and  
expansion engines. Normal practice is to separate  
brine and steam and use only the latter, wasting the  
energy tied up in the brine. It would be far more ef-  
ficient to use the total flow, extracting energy from  
both brine and steam. But conventional turbines,  
designed to operate on pure steam, would quickly  
wear out or plug up with scale if exposed to brine.

77A48803 ISSUE 23 PAGE 3997 CATEGORY 44  
77/00/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Geothermal power cycle analysis  
AUTH: A/SCHAPIRO, A. R.; B/HAJELA, G. P. PAA: B/(Rockwell  
International Corp., Atomics International Div.,  
Canoga Park, Calif.)  
In: Intersociety Energy Conversion Engineering  
Conference, 12th, Washington, D.C., August  
28-September 2, 1977, Proceedings, Volume 1.  
(A77-48701 23-44) La Grange Park, Ill., American  
Nuclear Society, Inc., 1977, p. 857-864.  
MAJS: /-COST ANALYSIS/-ELECTRIC POWER PLANTS/-GEOTHERMAL  
ENERGY CONVERSION/-STEAM TURBINES/-THERMODYNAMIC  
EFFICIENCY  
MINS: / COST ESTIMATES/ ENERGY CONVERSION EFFICIENCY/ ENERGY  
TECHNOLOGY/ OPERATING TEMPERATURE/ SALINITY/ SYSTEMS  
ENGINEERING  
ABA: (Author)  
ABS: A study was conducted to analyze and select (from the  
direct steam flash, flash binary, and direct binary  
cycles) a power generation cycle producing 10 MW net  
electric power output, that has the lowest capital  
cost for two brine models: one for  
high-temperature/high-salinity brine and the other for  
low-temperature/low salinity brine. For each cycle,  
the thermodynamic performance and capital cost were  
analyzed. The materials of construction used in  
estimating the cost of the components were: (1) carbon  
steel and (2) materials selected for each component  
that shows promise for longer life. Estimates with  
components constructed of carbon steel were made to  
give an equal basis to the comparison. The effects of  
the materials of construction upon the cycle selected  
were ascertained.

77A48805 ISSUE 23 PAGE 3987 CATEGORY 44 CNT#:  
E(04-3)-1124 77/00/00 7 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Effect of reservoir temperature decline on geothermal  
power plant design and economics  
AUTH: A/HANKIN, J. W.; B/HOGUE, R. A.; C/CASSEL, T. A. V.;  
D/FICK, T. R. PAA: D/(Bechtel Corp., San Francisco,  
Calif.)  
In: Intersociety Energy Conversion Engineering  
Conference, 12th, Washington, D.C., August  
28-September 2, 1977, Proceedings, Volume 1.  
(A77-48701 23-44) La Grange Park, Ill., American  
Nuclear Society, Inc., 1977, p. 870-876  
MAJS: /-BRINES/-GEOTHERMAL ENERGY CONVERSION/-POWER PLANTS/-  
WATER TEMPERATURE  
MINS: / BLOCK DIAGRAMS/ CALIFORNIA/ CLEAN ENERGY/ COST  
ESTIMATES/ DESIGN ANALYSIS/ ELECTRIC POWER/ ENERGY  
TECHNOLOGY

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Wahl, Edward F.  
Geothermal energy utilization /  
Edward F. Wahl. New York : Wiley,  
c1977.

xiv, 302 p., [1] leaf of plates :  
ill. ; 24 cm.

'A Wiley-Interscience publication.'

Includes bibliographies and index.

1. Geothermal engineering. I.

Title.

621.4 77-546 0-471023-04-3 77V16652

## GEOTHERMAL - UTILIZATION (NONELECTRICAL)

### 14361 EAST MESA GEOTHERMAL TEST SITE

**KEY WORDS:** Corrosion; Desalting; Geothermal energy; Groundwater basins; Injection; Scale (corrosion); Subsidence; Temperature; Water quality; Wells

09936

**ABSTRACT:** Geothermal fluid with its inherent heat energy has the potential of providing high quality water for augmentation of the Colorado River system. Desalting tests have been conducted utilizing geothermal fluids at East Mesa on vertical tube evaporator and multistage flash distillation processes and a high temperature electrodialysis membrane process. Effective scale control has been developed by the use of a threshold treatment chemical. Considerable geophysical and geologic data have been collected and five deep geothermal wells have been drilled ranging in depths from 6,000 ft to 8,030 ft (1,829 m to 2,447 m). A microearthquake network and level network have been installed to monitor movement in the earth's surface structure. Injection has been successfully achieved to dispose of waste fluids, however, surface pumping is required. A national test site has been established at East Mesa in cooperation with the Department of Energy and a number of private and institutional experimenters have utilized the site facilities for research activities.

**REFERENCE:** Fernelius, Wayne A., and Fulcher, Martin K., "East Mesa Geothermal Test Site," *Journal of the Environmental Engineering Division, ASCE*, Vol. 105, No. EE1, Proc. Paper 14361, February, 1979, pp. 13-32

### A RETROFITTED GEOTHERMAL HEATING SYSTEM.

Clen Hull, Georgr Simmons.

Ashrae Journal, vo 21, no 5, May 1979, p. 45-50.

*The heating system at the Idaho State Health and Agriculture Laboratory was recently converted to run on geothermal energy. Analysis of the system, which exchanges geothermal energy with a closed water loop, was aided by computer simulation. Accuracy of the models was verified during one heating season. A new controller was specified and installed which lowers the loop temperature with increasing ambient temperature. Heating costs were significantly decreased.*

A79-40186 # Utilizing geothermal resources below 150 C /300 F/. J. F. Kunze (Energy Services, Inc., Rexburg, Idaho). (American Society of Mechanical Engineers, Energy Resources Technology Conference and Exhibition, Houston, Tex., Nov. 5-9, 1978.) ASME, Transactions, Journal of Energy Resources Technology, vol. 101, June 1979, p. 124-127. 5 refs.

Except for the steam-dominated geothermal field at Geysers, Calif., the use of geothermal energy in the U.S. has been minimal. There has been so much preoccupation with searching for the high temperature resources (above 350 F), for generating electricity, that the greatest potential for geothermal energy, that at temperatures below 150 C (300 F) has been largely ignored. These waters are much more abundant than the higher temperature ones, and therefore, represent 10 or more times as much usable energy than the total of the energy in all the high temperature waters. The problems have, in part, been technological - how to economically convert these lower temperature geothermal waters to useful energy - and in part institutional. This paper describes the last five year's program, largely centered at the Idaho National Engineering Laboratory, to make it more practical and economical to harness the lower temperature geothermal resources (Author)

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Annual review of earth and planetary sciences. v. 6 / Fred A. Donath, editor, Francis G. Stehli, associate editor, George W. Wetherill, associate editor. — Palo Alto, Calif. : Annual Reviews, 1978. 543 p. : ill.

Includes indexes.

1. Earth--Periodicals. 2. Planets--Periodicals. 3. Geophysics--Periodicals. I. Donath, Fred A. II. Stehli, Francis G. III. Wetherill, George W.

HYDROTHERMAL ALTERATION IN ACTIVE GEOTHERMAL FIELDS, P. R. L. Browne 229

79A50897 ISSUE 22 PAGE 4188 CATEGORY 44  
78/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: The consumptive use of water in geothermal energy applications

AUTH: A/KUNZE, J. F.; B/SPENCER, S. G. PAA: A/(Forsgren, Perkins, and Associates, Rexburg, Idaho); B/(EG&G Idaho, Inc., Idaho Falls, Idaho)  
In: Conference on Environmental Aspects of Non-Conventional Energy Resources - II, Denver, Colo., September 26-29, 1978. Proceedings. (A79-50876 22-45) La Grange Park, Ill., American Nuclear Society, 1978, p. 39-3 to 39-8.

MAJS: /\*GEOTHERMAL ENERGY CONVERSION/\*GEOTHERMAL RESOURCES/\*WATER CONSUMPTION

MINS: / CLEAN ENERGY/ COOLING/ ENERGY TECHNOLOGY/ WATER INJECTION

ABA: (Author)

ABS: Water is the prime environmental concern for the future development of geothermal resources in the United States. The central questions concern the use of water, injection, and effects on conventional water supplies. The annual regional water requirements for projected geothermal developments in the year 2000 could consume in excess of  $1.8 \times 10$  to the 6th acre-ft/yr ( $2.2 \times 10$  to the 9th cu m/yr). Alternative cooling methods which consume little or no water are available and should be considered for future geothermal developments.

Prog. Energy Combust. Sci., v.3, 1977, p.73-103.

## NON-ELECTRICAL USES OF GEOTHERMAL ENERGY

ENRICO BARBIER and MARIO FANELLI

National Research Council,  
International Institute for Geothermal Research,  
Lungarno Pacinotti 55, Pisa, Italy.

**Abstract**—The non-electric applications of geothermal energy, with the exception of balneology, date back the nineteenth century and have been given a new impetus by the recent oil crisis.

In general, water or water-steam mixtures at temperatures between 20 and 180 C are used for the applications.

The search for geothermal fluids draws on techniques from hydrogeology, geochemistry and geophysics the same techniques as applied to the search for cold waters, together with some specific methods connect with the underground thermal conditions.

Geothermal energy is used in agriculture, aquaculture, district heating and cooling and various industrial applications. The power associated with these uses throughout the world at present can be estimated at 62 MW and future prospects are by now promising and of definite economic interest.

The environmental impact from geothermal energy is lower than that caused by conventional energy sources. ReInjection of used fluids back into the underground may, however, solve pollution problems.

77A47600 ISSUE 22 PAGE 3814 CATEGORY 44  
77/09/08 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Geothermal energy - Tapping nature's boiler room

AUTH: A/ARONSON, R. B.  
Machine Design, vol. 49, Sept. 8, 1977, p. 28-30, 32-34.

MAJS: /\*ENERGY TECHNOLOGY/\*GEOTHERMAL ENERGY CONVERSION/\*HYDROGEOLOGY/\*WATER VAPOR

MINS: / ECOLOGY/ ELECTRIC POWER PLANTS/ GEOTHERMAL RESOURCES / HEAT EXCHANGERS/ HEAT TRANSFER/ HEATING EQUIPMENT/ MAGMA/ STRATIGRAPHY/ WELLS

ABA: S.C.S.

ABS: An analysis of possible applications of geothermal energy is presented, including several non electric projects such as home and space heating, mineral recovery, desalination plants, aquatic farming, and waste processing. The location and evaluation of geothermal reservoirs is outlined in terms of drilling, fluid supply, and subsidence. Geothermal hardware is described, along with the identification of potential ecological problems, and three sources of obtaining geothermal energy are studied: the magma, hydrothermal, and hot dry rock systems. Possible power systems are discussed (the flashed steam, binary, and total flow systems) together with institutional problems of a legalistic nature.

78A16635 ISSUE 4 PAGE 629 CATEGORY 44 77/00/00  
31 PAGES UNCLASSIFIED DOCUMENT

UTTL: Non-electrical uses of geothermal energy

AUTH: A/BARBIER, E.; B/FANELLI, M. PAA: B/(CNR, Istituto Internazionale per la Ricerche Geotermiche, Pisa, Italy)

Progress in Energy and Combustion Science, vol. 3, no. 2, 1977, p. 73-103.

MAJS: /\*DOMESTIC ENERGY/\*GEOTHERMAL ENERGY CONVERSION/\*HEATING EQUIPMENT/\*INDUSTRIAL ENERGY/\*TECHNOLOGY UTILIZATION

MINS: / CLEAN ENERGY/ ENERGY TECHNOLOGY/ EUROPE/ GEOCHEMISTRY/ MINERAL EXPLORATION/ WASTE DISPOSAL

ABA: S.D.

ABS: Exploration techniques, extraction, and uses of low-enthalpy geothermal fluids in different countries for nonelectric applications in the temperature range 50-160 C are outlined. At present the nonelectric applications utilize either hot water or water-steam mixtures. Attention is directed at the use of geothermal energy in agriculture, aquaculture, climate control, balneology, district heating and cooling, and various industrial applications. The consumption of geothermal energy for nonelectric applications throughout the world is about 6200 MW. Elimination of pollution by proper disposal of waste fluids is also examined.

**ON THE STATUS OF RESEARCH LEADING TOWARD  
VOLCANO ENERGY UTILIZATION. Augustine S.  
Furumoto and Zozo Yuhara**

**Critical Reviews in Environmental Control.  
Vol. 6, Issue 4, Oct. 1976, p. 371-400**

**TJ      Birsic, Rudolph J.  
280.7      More about geothermal steam: or, the  
.B62      hottest energy prospect ever. [By]  
         Rudolph J. Birsic. Fullerton, Calif.,  
         the author, 1976.  
         iv, 172 p. : ill.  
         1. Geothermal resources. 2.  
         Geothermal engineering. I. Title: The  
         hottest energy prospect ever. II. Title:  
333.8    77V33640**

## GEOTHERMAL - ENVIRONMENTAL ASPECTS

79A37853 ISSUE 15 PAGE 2789 CATEGORY 44  
79/0C/00 4 PAGES UNCLASSIFIED DOCUMENT

- UTTL: The problem of fouling in the utilisation of geothermal energy
- AUTH: A/BOTT, T. R.: B/GUDMUNDSSON, J. S. PAA:  
A/(Birmingham, University, Birmingham, England);  
B/(Orkustofnun, Reykjavik, Iceland)  
In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979. Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 65-68. Research supported by the Science Research Council and Atomic Energy Research Establishment.
- MAUS: /CORROSION/FOULING/GEOTHERMAL ENERGY CONVERSION/  
HEAT EXCHANGERS/WASTE ENERGY UTILIZATION/WATER TREATMENT
- WINS: /CARBON STEELS/CLEANERS/COPPER ALLOYS/DEPOSITION/  
GEOTHERMAL RESOURCES/PRESSURE EFFECTS/STAINLESS STEELS/TEMPERATURE EFFECTS/THERMAL ENERGY
- 1BA: B.J.
- 1BS: Problems associated with solids deposition and corrosion in geothermal waters are considered. Experimental work on deposition is reviewed and attention is given to some possible solutions to the deposition problem. Including pretreatment of geothermal water, cleaning techniques, and alternative heat exchanger designs. It is concluded that the development of novel heat exchangers is imperative, the direct contact heat exchanger appearing to be the most likely development.

**A79-37853** The problem of fouling in the utilisation of geothermal energy. T. R. Bott (Birmingham, University, Birmingham, England) and J. S. Gudmundsson (Orkustofnun, Reykjavik, Iceland). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 65-68. 12 refs. Research supported by the Science Research Council and Atomic Energy Research Establishment.

Problems associated with solids deposition and corrosion in geothermal waters are considered. Experimental work on deposition is reviewed and attention is given to some possible solutions to the deposition problem, including pretreatment of geothermal water, cleaning techniques, and alternative heat exchanger designs. It is concluded that the development of novel heat exchangers is imperative, the direct contact heat exchanger appearing to be the most likely development.

B.J.

**GEOTHERMAL ENERGY IN IMPERIAL COUNTY CALIFORNIA: ENVIRONMENTAL. SOCIO-ECOMMENDATION**, by M. R. Pasqualetto, J. B. Pick and E. W. Butler.  
Energy vol. 4, no. 1, Feb, 1979, p.67-81.

**Abstract**—It is estimated that thousands of megawatts of electricity could be generated from the geothermal fluids which underlie agricultural fields in Imperial County, California. Many potential environmental problems appear generally controllable. The possible inter-relationships between geothermal development and subsidence, seismicity, and water availability are, however, difficult to predict, and evaluation must await long-term, commercial-sized operations. County population will interact with energy development through employment, geographical distribution, and interaction with the larger Mexican labor pool. Exportation of the bulk of the generated electricity, however, will limit the local socio-economic impact. County residents favor geothermal development at a ratio of almost 9:1. Thirteen policy recommendations applicable to other KGRA's in the western U.S. include: the desirability of positive public opinion, the encouragement of on-line electrical power at an early stage in the development process, the importance of determining economic-technological exploitation feasibility, and the influences of local, state, and federal regulations.

**A79-50351** Environmental implications for geothermal energy development. R. B. Craig and G. W. Suter, II (Oak Ridge National Laboratory, Oak Ridge, Tenn.). In: Learning to use our environment; Proceedings of the Twenty-fifth Annual Technical Meeting, Seattle, Wash., April 30-May 2, 1979. (A79-50326 22-42) Mount Prospect, Ill., Institute of Environmental Sciences, 1979, p. 302-305. 15 refs. Contract No. W-7405-eng-28.

The nature of geothermal resources and the constraints that site characteristics place on their development are examined. The five types of geothermal energy, magma, normal gradient, hot dry rock, hydrothermal, and geopressurized are discussed, noting that the last three types have potential for near future development. Remoteness of hydrothermal areas which often conflicts with preservation of biological values is considered, and it was found that the most common characteristics of geothermal resource areas is limited water. It was shown that the characteristics of a geothermal field development are drilling activity, water evaporation, a conspicuous plant with cooling towers, dirt roads, pipelines, and transmission lines which interfere with cultural, aesthetic, and wildlife resources. Thus, proper site selection and environmental planning will decide the success of geothermal energy commercialization.

A.T.

QC Symposium on Turbulence, Diffusion, and Air  
 880.4 Pollution, 4th, Reno, Nevada, 1979.  
 .T8 Fourth Symposium on Turbulence, Dif-  
 S9 fusion and Air Pollution, January 15-18,  
 1979, Reno, Nevada : preprints / American  
 Meteorological Society. — Boston ; AMS,

# SESSION 3A: GEOTHERMAL ENERGY AND COOLING TOWER STUDIES

CHAIRMAN: Todd V. Crawford, E. I. du Pont de Nemours & Co., Aiken, S.C.

- 3.1 THE INFLUENCE OF ROUGH TERRAIN ON POLLUTANT DISPERSION AND TRANSPORT FROM A GEOTHERMAL POWER COMPLEX. Ronald E. Ruff, SRI International, Menlo Park, Calif. 122
- 3.2 THE GEYSERS GEOTHERMAL AREA EMISSIONS AND AEROMETRIC DATA BASE AND AIR QUALITY ANALYSIS. D. E. Steffen, G. M. Hidy, L. K. Wang, and E. A. Berman, Environmental Research & Technology, Inc., Westlake Village, Calif. 128

79A14114 ISSUE 3 PAGE 425 CATEGORY 45 78/00/00  
 6 PAGES UNCLASSIFIED DOCUMENT  
 UTTL: Pollution perspective for geothermal energy development  
 AUTH: A/HARTLEY, R. P. PAA: A/(U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory, Cincinnati, Ohio)  
 In: Energy and the environment: Proceedings of the Fifth National Conference, Cincinnati, Ohio, November 1-3, 1977. (A79-14106 03-45) Dayton, Ohio, American Institute of Chemical Engineers, 1978. p. 243-246.  
 MAJS: /ENERGY TECHNOLOGY/ENVIRONMENT POLLUTION/GEOTHERMAL ENERGY CONVERSION/POLLUTION CONTROL  
 MINS: / HYDROGEN SULFIDE/ SALINITY/ WATER RECLAMATION  
 ABA: B.U.  
 ABS: Hydrogen sulfide releases and wastewaters high in dissolved solids are the principal potential sources of pollution in the geothermal energy field. Wastewater characteristics are relatively constant for a given reservoir, which is an advantage in designing treatment and disposal systems. Two major control technology areas have evolved: the treatment of noncondensable gases and the subsurface injection of wastewater. The latter, if successful, will eliminate the need for wastewater treatment and assist in reservoir maintenance and subsidence control.

SULFUR EMISSION CONTROL FOR GEOTHERMAL POWER PLANTS,  
 KEY WORDS: Hydrogen sulfide emissions; geothermal power; Claus plant  
 By John A. Velker and Robert C. Axtmann  
 Journal of Environmental Science and Health, Part A  
 Environmental Science and Engineering, vol. A13, no. 8  
 1978, p. 603-613

Hydrogen sulfide gas is present in hydrothermal waters that are useful for electric power production. Previous schemes for H<sub>2</sub>S emission control increase the costs of geothermal power. A modification of the classical Claus process for producing sulfur from H<sub>2</sub>S is compatible with many geothermal plant designs. In the presence of a market for sulfur, use of the process could decrease geothermal power costs.



79N10604# ISSUE 1 PAGE 80 CATEGORY 45 RPT#:  
PB-282546/1 EPA-607/7-78-101 78/06/00 149 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Pollution control guidance for geothermal energy development

AUTH: A/HARTLEY, R. P.  
CORP: Industrial Environmental Research Lab., Cincinnati, Ohio. AVAIL.NTIS SAP: HC A07/MF A01

MAJS: /\*ENVIRONMENT EFFECTS/\*GEOTHERMAL ENERGY CONVERSION/\*  
POLLUTION CONTROL

MINS: / AIR POLLUTION/ ELECTRIC POWER PLANTS/ NOISE  
POLLUTION/ REGULATIONS/ WATER POLLUTION

ABA: GRA

ABS: The EPA regulatory approach toward geothermal energy development is summarized. The state of knowledge is described with respect to the constituents of geothermal effluents and emissions, including water, air, solid wastes, and noise. Pollutant effects are discussed. Pollution control technologies that may be applicable are described along with preliminary cost estimates for their application. Finally, discharge and emission limitations are suggested that may serve as interim guidance for pollution control during early geothermal development.

80N12575# ISSUE 3 PAGE 356 CATEGORY 44 RPT#:  
ORNL/TM-6533 CNT# W-7405-ENG-26 78/12/00 159  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Waste heat rejection from geothermal power stations

AUTH: A/ROBERTSON, R. C.  
CORP: Oak Ridge National Lab., Tenn. CSS: (Energy Div.)  
AVAIL.NTIS SAP: HC A08/MF A01

MAJS: /\*GEOTHERMAL ENERGY CONVERSION/\*POWER PLANTS/\*WASTE  
ENERGY UTILIZATION

MINS: / COST ANALYSIS/ EFFICIENCY/ HEAT TRANSFER

ABA: DOE

ABS: Waste heat rejection from geothermal power stations is concerned only with the heat rejected from the power cycle. The heat contained in reinjected or otherwise discharged geothermal fluids is not included with the waste heat considered here. The heat contained in the underflow from the flashtanks in such systems is not considered as part of the heat rejected from the power cycle. By following this definition of the waste heat to be rejected, various methods of waste heat dissipation are discussed without regard for the particular arrangement to obtain heat from the geothermal source. Recent conceptual design studies made for 50 MW(e) geothermal power stations at Heber and Niland, California, are of particular interest. The former uses a flashed-steam system and the latter a binary cycle that uses isopentane. In last-quarter 1976 dollars, the total estimated capital costs were about \$750/kW and production costs about 50 mills/kWhr. If wet-dry towers were used to conserve 50% of the water evaporation at Heber, production costs would be about 65 mills/kWhr.

78A44149 ISSUE 19 PAGE 3514 CATEGORY 45 CNT#:  
W-7405-ENG-48 78/06/00 6 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Geothermal perturbations on the atmospheric environment

AUTH: A/KELLY, R. E. PAA: A/(Mississippi University, University, Miss.)

MAJS: /\*AIR POLLUTION/\*AIR QUALITY/\*ENVIRONMENT EFFECTS/\*  
GEOTHERMAL ENERGY CONVERSION

MINS: / ATMOSPHERIC TEMPERATURE/ CHEMICAL REACTIONS/  
DISPERSING/ HUMIDITY/ PLUMES/ STACKS/ TEMPERATURE  
INVERSIONS

ABA: M.L.

ABS: A simple but not precise procedure for using existing meteorological data to predict air quality changes due to geothermal sources is explained. Since geothermal sources emit large amounts of water vapor and heat, the procedure is concerned with predicting changes in relative humidity and temperature. Modifications caused by atmospheric inversions and, hence, stack heights are examined, and the effects of particulate settling, chemical reactions, and radioactive decay are studied. The statistical Gaussian equation for dispersion is applied in the mathematical method used to calculate pollution concentration as well as temperature and relative humidity changes by an emitted plume. The procedure is used to predict characteristics of Imperial Valley, California, installations.

## REMOVING H<sub>2</sub>S FROM GEOTHERMAL STEAM

G.E. Coury and M. Vorum  
Chemical Engineering Progress  
Vol. 73, no.9, September 1977,  
p. 93-98.

In the process described here, the H<sub>2</sub>S is absorbed in an aqueous solution of copper salts by precipitating copper sulfides. The copper is recovered from the precipitate by roasting in a fluid-bed reactor and is recycled to the absorber. Ammonia, which is also often present in geothermal steam, is absorbed simultaneously and partially neutralizes the acidic solution formed as the H<sub>2</sub>S is dissolved. The net products from the process are the soluble sulfate and sulfate salts of ammonia. Geothermal installations are generally found in remote locations, and disposal of waste water can pose a serious problem. Thus, it may be necessary to dispose of cooling tower blowdown by injection into deep wells to a cool underground formation.

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## SOLAR - GENERAL

TH  
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.L8

**Lucas, Ted**

How to build a solar heater: a complete guide to building and buying solar panels, water heaters, pool heaters, barbecues, and power plants / Ted Lucas. Pasadena, [Calif.] : Ward Ritchie Press, 1975.

xi, 236 p. : ill. ; 22 cm.

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TJ  
810  
.W55

**Williams, J**

**Richard**

Solar energy; technology and applications, by J. Richard Williams. [Ann Arbor, Mich., Ann Arbor Science Pub. 1974]  
ix, 120 p. illus. 24 cm.  
1. Solar energy.

**N80-14539/ PRC Energy Analysis Co., McLean, Va.  
ENGINEERING CONCERNS IN SOLAR SYSTEM DESIGN  
AND OPERATION**

James L. Easterly Mar. 1979 24 p. refs  
(Contract EG-77-C-01-2522)

(SOLAR/0811-79/01) Avail: NTIS HC A02/MF A01

Engineering concerns associated with the startup and operation of solar heating and cooling installations are discussed. Recommendations are also made regarding the design and installation phases to help in avoiding these problems. DOE

**N79-32714/ Los Alamos Scientific Lab., N. Mex  
STATUS REVIEW OF THE TECHNOLOGY ASSESSMENT OF  
SOLAR ENERGY PROGRAM Interim Status Report**

John H. Altseimer and Robert P. Blaustein (DOE, Washington, D. C.) 1979 6 p. refs Presented at the Intern. Solar Energy Soc. Meeting, Atlanta, 28 May 1979

(Contract W-7405-eng-36)

(LA-UR-79-1369; Conf-790541-4)

HC A02/MF A01

Avail: NTIS

A number of emerging solar technologies and selected applications were assessed for the environmental, institutional, and social impacts resulting from the large scale deployment of decentralized solar technologies. Two national energy scenarios for the year 2000 were used, one predicting 6 quads of solar and the other 142 quads. A few results of a preliminary study of the system characterization data are given. DOE

"The Comprehensive Guide to Manufacturers & Service Organizations; Solar Industry Index;" published by the Solar Energy Industries Association, 1001 Connecticut Ave. NW, Suite 632, Washington, D.C. 20036. It sells for \$8.

**AE**      **Encyclopedia Britannica.**  
**5**      **Britannica book of the year, 1979. --**  
**.E364**      **Chicago : Encyclopedia Britannica, c1979.**  
**1979**      **768 p. : ill.**  
             **Includes index.**  
             **ISBN 0-85229-362-3**  
             **1. Encyclopedias and dictionaries--**  
             **Yearbooks. I. Title.**

**16**      **Feature article: Toward a Sun-Powered World**  
             The surprising ways in which the Sun can contribute toward the world's energy supply are discussed by a leading authority on the subject, *Paul Rappaport*, Director of the Solar Energy Research Institute.

#### 1979 SOLAR BUYERS GUIDE.

Solar Heating & Cooling, vol. 4, no. 2, 1979, p.A-1-A-43.

A listing of products by major categories  
 An alphabetical listing of the companies manufacturing these products  
 A listing by state of distributors of solar products  
 An alphabetical listing by city and state of solar builders, engineers, architects and installers

**N79-29609/** Committee on Government Operations (U. S. House).

#### **SOLAR ENERGY**

Washington GPO 1979 634 p. refs. Hearings before a Subcomm. of the Comm. on Government Operations, 95th Congr., 2d Sess., 12 May; 12-14 Jun. 1978  
 (GPO-36-957) Avail: Comm. on Government Operations

A general overview of the status of solar energy technology in the United States is given with emphasis on the state of California. Solar collectors, photovoltaics as well as biomass conversion and other less direct, but solar based technologies are discussed. Demonstration projects, in industrial as well as residential buildings, are included. Program goals, incentives, projected energy savings, and cost factors are among the factors considered  
 J.M.S.

A Global View of Solar Energy in Rational Units  
 by A. Rose

Physica Status Solidi (a), Vol. 56, No. 1, November 1979, p. 11-26

#### **1. Introduction**

#### **2. Limits to growth**

- 2.1 Power consumption
- 2.2 Limit to growth imposed by energy consumption
- 2.3 Power consumption via food
- 2.4 Limits to growth imposed by food

#### **3. Solar energy systems**

- 3.1 Introduction
- 3.2 General purpose solar energy systems
- 3.3 Solar energy systems for food
- 3.4 Comparative costs of solar energy
- 3.5 Concluding remarks

#### **4. Low cost solar cells**

- 4.1 Introduction
- 4.2 A "minimum" thin film cell
- 4.3 Tolerable densities of defect states
- 4.4 Recombination
- 4.5 Space-charge-limited currents
- 4.6 Open circuit voltage
- 4.7 General remarks

**A80-12428**      **Computers in the design of solar energy systems.** S. A. Klein, J. W. Mitchell, J. A. Duffie, and W. A. Beckman (Wisconsin, University, Madison, Wis.). *Energy* (UK), vol. 4, Aug. 1979, p. 483-501. 58 refs. NSF-supported research; Contract No. E(11-1)-2588.

The methodology developed for detailed simulations of solar energy systems is presented. Consideration is given to the development of models for several specific system components from which the simulation model of a system is composed. The models are formulated from basic engineering principles, and a sensitivity analysis is performed to find those simplifications which yield a computational efficient, yet accurate, solution. Three components, a collector, storage tank, and building structure, are used as examples. These components are then combined into a simulation model for the space and hot water heating system of the Solar House. The performance data available from this house is compared with the simulation results. Emphasis is placed on simplified design methods based on the results of detailed computer simulations.  
 V.T.

A wide range of issues in the engineering and economics of wind and solar energy is reviewed. It is concluded that the various effects of introducing these devices into conventional energy systems are only partially understood; the present analytical tools are rather limited in their ability to grasp the total problem. In the short run, engineering issues involving resource assessment and appropriate scale seem particularly important. The more complex problems of structural optimality in energy systems emerge only in a longer range perspective. Economic analysis should probably concentrate first on financial risk. Regulatory structure is an on-going area where policy research is fruitful.

Industrial Research/Development, vol. 21, no. 12,  
p. 35-36., December 1979.

Solid-state aspects of solar energy conversion systems are discussed, with attention given to spectrally selective surfaces, carrier lifetimes in silicon, solar photoelectrolysis with semiconductor

electrodes, heterojunction phenomena and interfacial defects in photovoltaic converters, and the Cu<sub>2</sub>S/CdS cell. The reviews include discussions of chemical vapor deposition of silicon, black-chrome electroplated coatings and semiconductor cermet films for photo-thermal converters, highly doped, highly conductive semiconductors for electrochemical solar cells, and the photoconductive decay technique for determining the carrier lifetime of a semiconductor crystal.

J.M.B.

Environment, vol 21, no 9, November 1979, p. 6-15  
con't on page 43.

The book is written in a narrative style and is a collection of essays by the Union of Communist Students, which will be published by Ballantine Publishing Company in July 1980. An English edition only was printed by David J. and David H. in the International Socialist Forum on an Account of the New York Times on November 14, 1977. The author would like to call the book "The Communist Party of the United States of America" and the book "The Communist Party of the United States of America" and the book "The Communist Party of the United States of America".

Physics Bulletin, vol 21, no 12, December 1978, p. 565  
566.

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1979

AMETEK Inc. Power Systems Group.  
Solar energy handbook : theory and  
applications / Power Systems  
Group/AMETEK Inc. Radnor, Pa. :  
Chilton Book Co., c1979.  
ix, 179 p. : ill. ; 29 cm.  
Includes index. Bibliography: p.  
171-174.  
1. Solar energy -- Handbooks,  
manuals, etc. I. Title.  
621.47 78-14646 0-801967-76-7  
79V48477

TJ      **McDaniels, David K., 1928-**  
 810      **The sun; our future energy source /**  
 .M17      **David K. McDaniels. New York : Wiley,**  
          **C1979.**  
          **xi, 271 p. : ill. ; 24 cm.**  
          **Includes bibliographies and index.**  
          **1. Solar energy. I. Title.**  
**621.47 78-12568 0-471045-00-4**  
**78V45291**

Let the Sun Shine  
 by L.M. Pruce

Power, Vol. 123, No. 5, May 1979, p. 33-37

**Harnessing tomorrow's energy sources gets increasingly urgent priority as reserves of conventional fuels dwindle. Article examines potential and problems attending solar and wind energy and fuel cells, suggests the promise of solar energy appears best for both utility and industrial plants**

**SOLAR ENERGY SYSTEMS AND THE CONSUMER, by Richard H. Montgomery.**  
**Solar Heating & Cooling, vol. 4, no. 2, 1979, p.11-15.**

A solar energy system built in 1979 will provide the average homeowner with energy for less money than an electric, a fuel oil, or a gas heating system over the next ten years.

Calculations show that, for a typical home, solar heating costs over the next decade could be up to 94% cheaper than fuel oil, 30% cheaper than natural gas, and of course, far, far cheaper than electricity.

Only six short months ago, a number of different studies showed that solar energy was only competitive with electricity. What has happened to change the energy cost picture so drastically and so quickly?

**38117      Engineer's guide to solar energy. Howell, Y.; Bereny, J.A. (comps.). San Mateo, CA; Solar Energy Information Services (1979). 330p.**

A comprehensive compilation of practical solar energy information that can serve as a learning aid, a training manual, a working tool, or a reference guide is presented. The guide offers information on the following subjects: (1) an overview of the six basic solar technologies, (solar heating and cooling, photovoltaics, wind energy conversion, solar thermal electric conversion, ocean thermal energy conversion, and biomass); (2) a comprehensive discussion of the solar resource, including a compendium of worldwide solar radiation data; (3) an introduction to passive solar technology; (4) extensive discussion of active solar systems, including applications for heating swimming pools, domestic hot water, and space heating; (5) methodology for calculating building heat loss and gain, including worldwide design temperature data; a comprehensive introduction to solar system sizing through utilization of the f-chart method, including examples and worksheets; (7) a Solar Heating Product Directory divided into four sections: collectors, controls, pumps, and storage; (8) an Annotated Bibliography highlighting significant solar heating literature, including vital program and planning documents published by the U.S. Government; and (9) a four-part Solar Dictionary consisting of: glossary, acronyms, nomenclature and conversion factors (English to metric SI units). (WHK)

**NSO-13899/ Midwest Research Inst., Golden, Colo.**  
**REVIEW OF SOLAR ENERGY Annual Report, 1977**  
 Oct. 1978 179 p refs  
 (Contract EG-77-C-01-4042)  
 (SERI/TR-54-066) Avail: NTIS HC A09/MF A01

A general review of national solar energy programs is provided. An executive summary and a brief history of the Federal solar energy program are presented. The issues and implications of the National Energy Plan that relate to solar energy development are discussed. The present Federal solar energy program is discussed, including the activities of several Federal agencies outside the Department of Energy. Some of the non-Federal solar energy programs are reviewed, including international programs in which the U.S. has some role, programs of state and local governments, college and university programs, the work of private industry, and individual and small scale activities. A synopsis of the major categories of solar technology is provided. A synopsis of major energy events of 1977: a glossary of technical terms, abbreviations, and acronyms, and a table of conversion factors are included. DOE

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1978

**International Symposium-Workshop on Solar Energy, Cairo, 1978.**  
International Symposium-Workshop on Solar Energy : [symposium lectures], 16-22 June 1978, Cairo, Egypt / presented by Clean Energy Research Institute, University of Miami, Florida ; sponsored by National Science Foundation ; edited by T. Nejat Veziroglu, Homer W. Hiser. -- [s.l.:s.n., 1979?]  
xi, 571 p. : ill.  
Cover title  
Includes bib- liographies.

**Business Week, no. 2555, p. 88-102 Oct. 9, 1978**  
**THE COMING BOOM IN SOLAR ENERGY. (Special report)**

### Solar energy

Solar energy is inefficient and expensive when compared with most other means of generating power. It competes economically only in certain limited circumstances. No single, big technological breakthrough is on the horizon, nor will costs come down dramatically in the near term. And solar power will not fit neatly into the huge, centralized U.S. power grid. Yet for all these drawbacks, solar power is on the threshold of a boom that may well transform it into a key energy source by the turn of the century.

**SAMPE Quarterly, v. 10, no. 1 Oct. 1978**

**MATERIALS APPLICATIONS IN ADVANCED ENERGY SYSTEMS Special Issue - 10th Anniversary Issue.**

**MATERIALS PROBLEMS IN SOLAR AND NUCLEAR ENERGY AND STORAGE OF ENERGY.....27**

R. S. Claassen

**SOLAR ENERGY: BONANZA OR BUNFIGHT?**  
David Dickson  
Nature, vol. 273, no. 5657 4 May 1978  
p. 2-3

David Dickson describes the background to President Carter's announcement of a major boost to the US solar energy effort

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**International Solar Forum, 2nd, Hamburg, 1978.**  
Internationales Sonnenforum = International Solar Forum : 12-14 July 1978, Congress Centrum Hamburg : [proceedings] / Coopération Méditerranéenne de l'Energie Solaire, Deutsche Gesellschaft für Sonnenenergie e.V. -- München : DGS, c1978.  
3 v. : ill.  
"Preparation of the proceedings: A. Derichsweiler, H. Krinninger."  
In German, French, English.  
Includes bib- liographical references and index.

1. Solar energy--Congresses. 2. Solar heating--Congresses. I. Derichsweiler, A. II. Krinninger, H. III. Coopération Méditerranéenne de l'Energie Solaire. IV. Deutsche Gesellschaft für Sonnenenergie e.V. V. Title. VI. Title: International Solar Forum.

**NTIS-336884/ United Nations Industrial Development Organization, Vienna (Austria).**  
**TECHNOLOGY FOR SOLAR ENERGY UTILIZATION**  
Hans Kleinrath, U. G. Bhade, and Jean Paul Durand 1978  
180 p. Sponsored in part by Agency for International Development  
(PB-296572/1) Avail: NTIS HC A08/MF A01 CSCL 10A  
Work being done in various countries and institutions dealing with: (1) the conversion of solar energy into mechanical or electrical energy, (2) the design of solar collectors, (3) the utilization of solar energy in heating, cooling, distillation, drying and cooking, and (4) the transfer of technology is presented. GRA

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**Energy from the Sun : a survey of technologies for collection, conversion, storage, utilization : symposium papers, April 3-7, 1978, IIT Research Institute auditorium, Chicago, Illinois / symposium chairman, William F. Rush ; symposium director, Wendell W. Waterman ; sponsored by Institute of Gas Technology ; produced by Jack W. White, Wilma McGrew, and Susan Malone. -- Chicago : Institute of Gas Technology, 1978.**

vi, 500 p. : ill. ; 23 cm.  
Includes bibliographical references.  
\$40.00

1. Solar energy -- Congresses. I. Rush, William F. II. White, Jack W. III. McGrew, Wilma. IV. Malone, Susan. V. Chicago. Institute of Gas Technology.  
TJ810.E55 621.47 78-107014

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1978

**Optics applied to solar energy IV, August 30-31, 1978, San Diego, California / Keith D. Masterson, editor ; cooperating organization, American Meteorological Society. -- Bellingham, Wash. : Society of Photo-optical Instrumentation Engineers, cl978.**

vi, 114 p. : ill. -- (Proceedings of the Society of Photo-optical Instrumentation Engineers ; v. 161)

Includes bibliographical references and index.

1. Solar energy--Congresses. 2. Optics--Congresses. I. Masterson, Keith D. II. Society of Photo-optical Instrumentation Engineers. III. American Meteorological Society. IV. Series: Society of Photo-optical Instrumentation Engineers. Proceedings ; v. 161.

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**International Solar Energy Congress, New Delhi, India, 1979.**

Sun, mankind's future source of energy : proceedings of the International Solar Energy Congress, New Delhi, India, January 1979. v. 1 / edited by Francis deWinter and Michael Cox. -- New York : Pergamon Press, cl979.

1 v. : ill.

1. Solar energy--Congresses. I. DeWinter, Francis. II. Cox, Michael.  
III. Title. 621.7

A78-25718 Solar economics comes home. M. Hyman, Jr. (Solar Heat Corp., Arlington, Mass.). *Technology Review*, vol. 80, Feb. 1978, p. 28-35.

Rising fossil fuel costs have made solar heating systems increasingly attractive. Such a system is evaluated in terms of a two-storey frame house in Massachusetts, which was outfitted with 1,200 sq ft of absorbing surface. The system was designed to provide up to 100% of the house's heating requirements and up to 90% of its hot water. The rest would be taken up by conventional fuel sources. A description of the system parameters is presented, and correlated with seasonal sunlight and temperature variations. Performance was approximately as expected, but the long time span necessary for the system to amortize (25-30 years) makes it economically questionable at this point.  
D.M.W.

N79-11548 (V.1)

**United States. Congress. Office of Technology Assessment.**

Application of solar technology to today's energy needs. -- Washington : Congress of the United States, Office of Technology Assessment : for sale by the Supt. of Docs., U.S. Govt. Print. Off., 1978-

v. : ill. ; 27 cm.

"OTA-E-66."

Includes bibliographical references.

1. Solar energy-- United States. 2. Energy policy-- United States. I. Title.  
TJ810.U57 1978 333.7 78-600060



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**Kreith, Frank**

**Principles of solar engineering / Frank Kreith, Jan F. Kreider. — Washington : Hemisphere Pub. Corp., c1978.**  
xii, 778 p. : ill. — (Series in thermal and fluids engineering)  
Bibliography: p. 765-767.  
Includes index.

Combining a basic technical understanding with an appreciation of the economic aspects of utilizing nonrenewable energy sources, the authors present the results of pioneering research work in the problems of solar energy conversion.

Beginning with the fundamentals of heat transfer and solar radiation, this text proceeds to applications that stress systems analysis and modeling with component interactions. Included are detailed thermal and optical analyses of ten solar collector types, both concentrating and nonconcentrating, assessments of the economic impact of solar systems through discounted cash-flow analysis, life-cycle costs, and cost-benefit analysis and optimization. Practical examples are provided throughout to illustrate principles and concepts as they are presented.

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262 pages, paperbound (C 1978) . . . . \$6.95

**1978 SOLAR BUYERS GUIDE.**  
Solar Heating & Cooling, v.3, no.1, Feb.1978.

24	Solar Market Forecast
27	1978 Solar Buyers Guide
28	Manufacturers of Solar Products
60	Distributors of Solar Products
90	Solar Builders, Engineers, Architects and Installers

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**Kreith, Frank**

**Principles of solar engineering / Frank Kreith, Jan F. Kreider. — Washington : Hemisphere Pub. Corp., c1978.**  
xii, 778 p. : ill. — (Series in thermal and fluids engineering)  
Bibliography: p. 765-767.  
Includes index.  
ISBN 0-891160-45-0  
1. Solar energy. I. Kreider, Jan F., 1942- joint author. II. Title. III. Series. 621.47

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**Vaillant, J. R.**

**Utilisations et processus de l'énergie solaire / par J. R. Vaillant. — 2d ed. — Paris : Editions Eyrolles, 1978.**  
502 p. : ill. — (Collection du B. C. E. O. M.)  
Includes bibliographical references and index.  
1. Solar energy. 2. Power resources. I. Title.

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Montgomery, Richard H.  
The solar decision book : your guide to  
making a sound investment / by Richard H.  
Montgomery with Jim Budnick. -- Midland,  
Mich. : Dow Corning Corp., c1978.  
305 p. in various pagings : ill.  
ISBN 0-9601876-1-8.  
1. Solar heating. 2. Solar energy. I.  
Budnick, Jim. II. Title.

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International Solar Energy Congress, New  
Delhi, India, 1978.  
Sun, mankind's future source of energy :  
proceedings of the International Solar  
Energy Congress, New Delhi, India, January  
1978. v. 2 / edited by Francis deWinter  
and Michael Cox. -- New York : Pergamon  
Press, c1978.  
1 v. : ill.  
1. Solar energy--Congresses. I. DeWinter,  
Francis. II. Cox, Michael.  
III. Title. 621.7

A79-16451 International Symposium-Workshop on Solar  
Energy, Cairo, Egypt, June 16-22, 1978, Symposium Lectures.  
Symposium-Workshop sponsored by the National Science Founda-  
tion. Edited by T. N. Veziroglu and H. W. Hiser (Miami, University,  
Coral Gables, Fla.). Coral Gables, Fla., University of Miami, 1978.  
580 p. \$50. (For individual items see A79-16452 to A79-16470)

The volume considers such topics as the economics and policy  
of alternative energy sources, solar collector design and performance,  
solar heating and cooling principles, thermal storage of solar energy,  
and integrated solar building system design. Papers are also presented  
on such topics as solar hydrogen production at high temperatures,  
solar energy transportation and production of hydrogenated fuels,  
the use of satellites in solar applications, solar-based agricultural  
systems for the Middle East, and solar energy planning for developing  
countries.

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NSO-12678/ Midwest Research Inst., Golden, Colo.  
DIRECT LABOR REQUIREMENTS FOR SELECT SOLAR  
ENERGY TECHNOLOGIES: A REVIEW AND SYNTHESIS  
B. Mason and K. Armington Aug. 1978 32 p refs  
(Contract EG-77-C-01-4042)  
(SERI/RR-53-045) Avail: NTIS HC A03/MF A01

Various estimates of the labor requirements for the design,  
manufacture, installation, and maintenance of space heating and  
domestic hot water systems are presented. Total projected job  
requirements by year, calculated by multiplying person-hours  
per system times market penetration estimated, are provided.  
Limitations of previous studies and conclusions about needed  
research are discussed. DOE

### Environmental Action Reprint Series

OVERCOMING LEGAL UNCERTAINTIES  
ABOUT THE USE OF SOLAR ENERGY  
SYSTEMS, by William A. Thomas, Alan S. Miller  
and Richard L. Robbins of the American Bar  
Foundation

This report identifies legal barriers to the use of  
solar energy systems and suggests appropriate  
legislative remedies. We can modify existing laws  
that impede the efficient use of solar energy and  
enact new legislation to guarantee essential rights  
and to induce private and public investments  
80 pages, paperbound (© 1978) \$5.00

TK  
2960  
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Neville, Richard C.  
Solar energy conversion : the solar  
cell / Richard C. Neville. Amsterdam  
; New York : Elsevier Scientific Pub.  
Co., 1978.  
x, 297 p. : ill. ; 25 cm. (Studies  
in electrical and electronic  
engineering ; 1)  
Includes bibliographies and index.  
1. Solar batteries. 2. Solar energy.  
I. Title. II. Series.

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.C52  
Cheremisinoff, Paul N.  
Principles & applications of solar  
energy / by Paul N. Cheremisinoff,  
Thomas C. Regino. Ann Arbor, Mich. :  
Ann Arbor Science Publishers, c1978 .  
vi, 249 p. : ill. ; 24 cm.  
Includes bibliographical references  
and index.  
I. Solar energy. I. Regino, Thomas  
C., joint author. II. Title.  
621.47 78-50308 0-250402-47-5  
78V51537

ASHRAE Journal, v.20, no.11.

Nov.  
1978

# SOLAR TECHNOLOGY: UPDATE '78 (Special Issue).

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W. Stephen Comstock	

Science News, v.113, no.16

Apr.22,  
1978

# SOLAR ENERGY. (Special issue).

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SERI comes of age	255
Sunat: Controversial but appealing	256
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Animal energy the reptilian way	260
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Japanese solar technology	263

A80-23511 Royal Society. Discussion on Solar Energy.  
London, England, November 15, 16, 1978, Proceedings. Royal  
Society (London), Philosophical Transactions, Series A, vol. 295, no.  
1414, Feb. 7, 1980. 168 p. (For individual items see A80-23512 to  
A80-23525)

Works covered include solar space heating with air and liquid  
systems, results of solar heating experiments, systematic design  
assessment techniques for solar buildings, and research at the  
building research establishment into the application of solar collec-  
tors for space and water heating in buildings. Other topics are  
examined such as heterojunction solar cells, photoelectrochemical  
cells and the microbial productions of energy sources from biomass.  
C.F.W.

32813 (PB-283770) Application of solar technology to today's  
energy needs. Volume 1. (Office of Technology Assessment (U.S.  
Congress), Washington, DC). Jun 1978. 522p. NTIS PC A22/MF  
A01.

This report reviews a range of solar energy systems designed  
to produce thermal and electrical energy directly from sunlight with  
units small enough to be located on or near the buildings they are  
designed to serve. It examines the state-of-the-art technology, identi-  
fies the circumstances under which such systems could be economi-  
cally attractive, and discusses the problems encountered in integrat-  
ing these devices into existing energy generation and delivery sys-  
tems. The study also assesses the impact that widespread use of  
decentralized solar energy equipment could have on the United  
States -- its energy supplies, its ability to achieve foreign policy  
objectives, its physical environment, its levels and patterns of em-  
ployment, and the functioning of the society as a whole.

**A79-17278** Sun: Mankind's future source of energy; Proceedings of the International Solar Energy Congress, New Delhi, India, January 16-21, 1978. Volumes 1, 2 & 3. Congress sponsored by the International Solar Energy Society and UNESCO. Edited by F. de Winter and M. Cox (Altas Corp., Santa Cruz, Calif.). Elmsford, N.Y., Pergamon Press, Inc., 1978. Vol. 1, 619 p.; vol. 2, 775 p.; vol. 3, 825 p. Price of three volumes, \$150. (For individual items see A79-17277 to A79-17525)

The volumes examine such topics as international and national solar energy programs, economic aspects of solar energy utilization, and policy, social, and implementation aspects of solar energy. Consideration is given to such technical aspects of solar energy utilization as solar radiation characteristics, energy storage, photovoltaics (including space power), photochemistry and photobiology, flat plate collectors (including solar ponds and selective surfaces), concentrating systems, solar heating and cooling, solar thermal power systems (including ocean thermal gradient systems), wind power, and agricultural and industrial applications of solar energy. B.J.

**A79-45201** \* Application of solar energy: Proceedings of the Third Southeastern Conference, Huntsville, Ala., April 17-19, 1978. Conference sponsored by the University of Alabama, NASA, Alabama Solar Energy Association, et al. Edited by S. T. Wu, D. L. Christensen, and R. R. Head (Alabama University, Huntsville, Ala.). Huntsville, Ala., UAH Press, 1978. 504 p. \$25. (For individual items see A79-45202 to A79-45231)

Demonstration projects, systems-subsystems simulation programs, applications (heating, cooling, agricultural, industrial), and climatic data testing (standards, economics, institutional) are the topics of the book. Economics of preheating water for commercial use and collecting, processing, and dissemination of data for the national demonstration program are discussed. Computer simulation of a solar energy system and graphical representation of solar collector performance are considered. Attention is given to solar driven heat pumps, solar cooling equipment, hybrid passive/active solar systems, and solar farm buildings. Evaluation of a thermographic scanning device for solar energy and conservation applications, use of meteorological data in system evaluation, and biomass conversion potential are presented. V.T.

**Public Utilities Fortnightly, v.102, Sept.28, 1978**  
no.7.

**ENERGY. (Special Issue).**

**Should Electric Utilities Market**

**Solar Energy? ..... Bruce M. Smackey 37**

A description of the possible roles which utility companies may assume in the promotion of solar energy use for meeting residential water heating needs.

**EMERGING ENERGY ALTERNATIVES FOR THE SOUTHEASTERN STATES.** Elias X. Stefanakos, ed. (Symposium sponsored by DOE, LaRC and NCA&TSU. Held NCA&TSU, Mar.31,1978) June 1978. 152p.

**Department of Energy,  
Washington, D.C.**

**NASA,**

**Langley Research Center  
North Carolina Agricultural and Technical  
State Univ., Greensboro, N.C.**

**ALTERNATIVES IN SOLAR ENERGY . . . . p.19 . . .**  
Donald G. Schueler

**Public Utilities Fortnightly,  
v 102, no.7.**

**Sept.28,  
1978**

**ENERGY ISSUE. (Special Issue).**

**Solar Energy — Will It Conserve Nonrenewable**

**Resources? ..... Seymour Baron 31**

Analyses of the consumption of fossil and nuclear energy resources needed to produce and operate solar energy systems point up the need to develop less energy-intensive solar systems to make them competitive with existing energy alternatives

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**Sun : A handbook for the solar decade :  
the official book of the first  
International Sun Day / edited by  
Stephen Lyons ; foreword by David R.  
Brover. — San Francisco : published  
in cooperation with Solar Action [by]  
Friends of the Earth, c1978.  
xiii, 364 p. : ill. ; 18 cm.  
Bibliography: p. 321-348.  
ISBN 0-913890-17-0 : \$2.95 (\$3.75  
Can)**

**1. Solar energy — Handbooks,**

# SOLAR ENERGY: POWER FOR TOMORROW.

James J. Haggerty

Aerospace, Vol. 16, No. 2, Summer 1978, p. 2-

6. Solar energy is a prime candidate for emphasis. The idea of tapping the sun for clean and limitless energy has almost universal appeal and seems the approach most likely to generate the broad public support necessary to the outlay of large sums of government money. Given such support, solar energy development in the remaining years of the 20th century could snowball into a program of Apollo-like proportions.

The initial steps are under way, and in the forefront of the development effort are the people who brought Apollo to fruition—the companies which comprise the U.S. aerospace industry. In some cases, these companies are directly applying aerospace technology to energy needs; in others, they are employing their general technological expertise to develop new types of solar energy systems for public use.

**FUTURE OF SOLAR ENERGY**, by Norman R. Sheridan.  
Sunworld, vol. 2, no. 3, August 1978, p.86-88.

*Solar needs new  
technology to reach  
its full potential.*

## THEORETICAL UPPER LIMIT TO THE CONVERSION EFFICIENCY OF SOLAR ENERGY, by J. E. Parrott Solar Energy, vol. 21, no. 3, 1978, p. 227-229

**Abstract**—The theoretical maximum useful work obtainable from solar energy has been calculated taking account of its directional character. The method employed is the calculation of the availability of a thermodynamic system containing such energy in an environment corresponding to the earth's surface. The corresponding efficiency is

$$1 - \frac{4T_a}{3T_s} (1 - \cos \delta) + \frac{1}{3} \left( \frac{T_a}{T_s} \right)^4$$

where  $T_a$  is the ambient temperature,  $T_s$  the equivalent solar temperature and  $\delta$  the half angle of the cone subtended by the sun's disc.

# QUO VADIS, SOLAR ENERGY?

Erich A. Farber

Building Systems Design, Vol. 75, No. 4, June/July 1978, p. 5-10.

**This paper discusses the state of the art of solar energy conversion into all the forms of energy which we use in daily life; the methods, pitfalls, and economic criteria. It shows the need for solar energy utilization; how it was used many years ago because it was economically advantageous; that many projects today are poorly engineered; that many, even though technically feasible, do not make economic sense; and that, eventually, we will have to return to methods and procedures which can be economically justified.**

## SOLAR ENERGY COMES OF AGE.

S.E. Bregman.

Environment, v.20, no.5, June 1978, p.25-31.

A78-30744

Utilities put the sun to work. R. Taylor (Electric Power Research Institute, Palo Alto, Calif.). *EPRI Journal*, vol. 3, Mar. 1978, p. 26-32.

A description is presented of investigations regarding the use of solar collectors in North Dakota. The described project is one of 458 active projects which were compiled during the summer of 1977 to determine the extent of solar energy research sponsored by electric utilities throughout the country. A substantial majority of the solar research projects deal with solar heating and cooling or related research. The survey also identified 34 wind projects, 28 projects dealing with solar data collection, 22 solar-thermal power generation projects, and 12 projects related to photovoltaics. Attention is given to problems of data collection, approaches for reducing the cost of wind energy, the testing of a collector system, a house constructed for obtaining solar energy information, a solar space conditioning system, the integration of solar electric systems, the utilization of solar heat in the cloudy northwest, and a study of the performance of 20 solar homes in northern California.

G.R.

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Guthrie, David L.  
A solar energy bibliography / David L.  
Guthrie and Robert A. Riley. — Rockville,  
Md. : Information Transfer Inc., c1978.  
xx, 360 p. ; 29 cm.  
1. Solar energy--Bibliography. I. Riley,  
Robert A., joint author. II. Title.

016.62147

#### THE SOLAR TRANSITION.

Barry Commoner  
Environment, Vol. 20, No. 3, April 1978, p.  
6-10 (con't on p. 13-15)

If all possible government initiatives were pursued, energy from solar sources could rapidly become economically feasible, given inevitable rise in the cost of fossil fuels. Government should also encourage the adoption of energy-using systems that are compatible with solar energy sources.

#### REGULATORY CONSTRAINTS ON SOLAR ENERGY AND THERMAL STORAGE INSTALLATIONS

Robert K. Koger  
Public Utilities Fortnightly  
Vol. 101, no. 2, January 19, 1978,  
p. 9-12.

Discusses public policy issues which the emergence of solar energy and thermal storage development, on a significant scale, will raise in regard to the interface of such systems with existing electric utility systems

A BRIGHT SOLAR PROSPECT SEEN BY CEQ AND OTA  
Luther J. Carter  
Science, vol. 200, no. 4342, May 12, 1978, p. 627-630

As it happens, new reports by the Administration's own Council on Environmental Quality (CEQ)—which under President Carter has been allowed to play somewhat the role of a gadfly—and the congressional Office of Technology Assessment (OTA) lend credence to the view that federal support for solar devel-

opment has not been nearly in keeping with this technology's promise. Both reports say that the technology is on the verge of a flourishing new phase but that, without aggressive federal support, its contribution to national energy supplies will fall far short of what now seems technically and economically achievable.

#### UTILITY ALTERNATIVES FOR SOLAR ENERGY

John K. Freeman  
Public Utilities Fortnightly  
Vol. 101 no. 1 January 5, 1978  
p. 20-23

*Solar energy: Is it a nothing, an opportunity, or a nemesis for the energy utility industries as they exist today? See some heuristic suggestions of the possibilities in this article.*

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#10  
.T35

Tagung über Heizen mit Sonne, 31, München, 1977.

Heizen mit Sonne. Band 2 : Praxisnahe Haustechnik / Tagungsbericht und Herausgeber : Ulf Bossel. — München : Deutsche Gesellschaft für Sonnenenergie e.V. (DGS), c1977.  
vii, 395 p. : ill.

"Dritte Tagung am 3. und 4. März 1977 in München."

1. Solar energy—Congresses. I. Bossel, Ulf. II. Deutsche Gesellschaft für Sonnenenergie e. (DGS). III. Title.

A79-13619 German Solar Energy Forum, 1st, Hamburg, West Germany, September 26-28, 1977, Proceedings. Volume 2 (Deutsches Sonnenforum, 1st, Hamburg, West Germany, September 26-28, 1977, Tagungsberichte. Volume 2). Forum sponsored by the Deutsche Gesellschaft für Sonnenenergie. Edited by U. Bossel. Munich, Deutsche Gesellschaft für Sonnenenergie, 1977. 603 p. \$23.54. (For individual items see A79-13620 to A79-13663) In German and English.

Consideration is given to such topics as solar collection techniques, collector testing, control units for solar energy systems, photoelectric conversion, solar power plants, and selective absorbing surfaces. Nonconventional energy sources such as wind energy, wave energy, and hydrogen-based energy are also considered. B.J.

TJ  
810  
.B43 Behrman, Daniel.  
Solar energy: the awakening science / Daniel Behrman ; photographs by Madeleine de Sinety. — Boston : Little, Brown and Company, c1976.  
408 p. : ill. ; 24 cm.

This book, written expressly for general readers, tells the story of solar energy since 215 B.C. to the present. What are the facts and true potential of this enormous, still largely unexplored source of renewable power?

The author takes us inside several houses that are heated or cooled through solar power. The energy potential of windmills and the equatorial oceans are examined. We are given reports on the progress of scientists and manufacturers toward making solar energy a viable competitor in the current energy market.

TJ810.S632 1977 RR

1977 SOLAR ENERGY & RESEARCH DIRECTORY. Prepared by Ann Arbor Science Special Task Group. 1977. Ann Arbor Science Publishers Inc, Box 1425, Ann Arbor, MI 48106, 386 pp., paper, \$22.50.

The compilers thoughtfully included a section at the beginning on How to Use the Solar Energy & Research Directory. Major classifications, cross-

reference system, subclassifications and subsystems and indexes are explained and listed. The largest sections are Manufacturers of Solar Components and Solar Research firms. Energy Conservation, Manufacturers of Solar Total Systems, Solar Energy—Related Areas, Design/ Construction, Residences or Buildings, and Distributors of Solar Products are the other categories.

# THE ECONOMICS OF UK SOLAR ENERGY SCHEMES. P.F. Chapman. Energy Policy, Dec.1977, p.334-

This paper establishes a framework for evaluating the cost-effectiveness of solar energy systems, using standard methods of discounted cash flow (DCF) analysis. Application of DCF analysis to solar energy requires that account is taken of its special nature and of its interactions with other components in energy supply systems. The discussion is

restricted to the use of solar energy in space and water heating in domestic dwellings, but the general approach is applicable to other solar systems and to other energy systems based on ambient energy. The procedures suggested for evaluating the cost-effectiveness of solar schemes also have important implications for their design.

TJ  
810  
.H37 Hayes, Denis, 1944  
Energy : the solar prospect / Denis Hayes. — Washington : Worldwatch Institute, 1977.  
79 p. ; 22 cm. — (Worldwatch paper

Dawn of an Era.

Solar Heating and Cooling. P= 67-79.

Electricity from the Sun. 19= 1. Title. II.

Catching the Wind.

Falling Water.

-916468-10-0 78V14234

Plant Power.

Storing Sunlight.

Turning Toward the Sun.

TJ  
810  
.C53

Chauliaguet, Charles  
L'energie solaire dans le bâtiment / par Charles Chauliaguet assiste de Pierre Baratsabal et Jean-Pierre Batellier. — Paris : Editions Eyrolles, c1977.  
2020 p. : ill. ; 25 cm.

1. Solar energy. 2. Architecture and solar radiation. I. Baratsabal, Pierre. II. Batellier, Jean-Pierre. II. Title.

621.47

TJ  
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.H39

A78-33026 Heat transfer in solar energy systems; Proceedings of the Winter Annual Meeting, Atlanta, Ga., November 27-December 2, 1977. Meeting sponsored by the American Society of Mechanical Engineers. Edited by J. R. Howell (Houston, University, Houston, Tex.) and T. Min (Michigan Technological University, Houghton, Mich.). New York, American Society of Mechanical Engineers, 1977. 139 p. \$20. (For individual items see A78-33027 to A78-33040)

Three broad fields are discussed: collector and storage design, experimental system evaluation, and analysis and simulation of systems. Particular papers are presented on the natural-convection characteristics of flat-plate collectors, preliminary performance evaluation of the New Mexico State University solar house, a study on solar water heating for existing homes in Southern New England, modeling and performance prediction of a solar-powered Rankine cycle/vapor compression cycle, and heat transfer analysis of the University of Virginia system for the annual collection and storage of solar energy.  
B.J.

TJ  
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.F57  
1976

Florida. State Energy Office. Data Collection and Analysis Section.

A Floridian's guide to solar energy / written by the State of Florida, Department of Administration, State Energy Office, Data Collection and Analysis Section ; [written and illustrated by Robert J. Pozzo, assisted by Lois A. Pollman]. -- Tallahassee : The Section ; Cape Canaveral : available from Florida Solar Energy Center, 1975. i.e. 1976.

vii, 120 p. : ill. ; 28 cm.  
Includes bibliographical references.

TJ  
810  
.I55

International Solar Energy Society. UK Section. Economic & commercial assessment of solar energy conversion : conference (C12) at the Royal Institution July 1977. -- London : UK - ISES, c1977.

98 p. : ill. ; 30 cm.

Includes bibliographical references.

1. Solar energy--Congresses.

The Economic Evaluation of Solar Energy Schemes  
P.F. CHAPMAN p.1

The Value of Solar Heating  
A.H. LANCASHIRE and K.R. WILLIAMS p.10

How Much Investment in Conversion Devices  
P.T. LANDSBERG p.20

Economics of Domestic Solar Energy in the UK - 1976  
D.J. TOOP p.28

The Heat Pump in Relation to Solar Energy  
J. KEABLE p.43

Cost Factors in Photovoltaic Energy Conversion with Solar Concentration  
J.E. PARROTT p.49

Solar Water Heating - Some Economic and Commercial Aspects  
B. McNELIS p.54

Economic Considerations in the Energy Supply of Autarkic Dwellings  
J.G.F. LITTLER and R.B. THOMAS p.64

Projected Market Penetration of Solar Heating and Cooling in the United States  
P.C. SPEWAK p.78

Solar Energy Development in the United States and the ERDA Programme  
R.A. PURPLE p.96



**SOLAR ENERGY SOURCE BOOK.** Hertz, C.W. (ed.). Washington, DC: Solar Energy Institute of America (1977). 712p.

An organized compilation of solar energy related products and services is provided for the building owner and solar building industry. The categories, products and services, are each subdivided into three sections: (1) the catalog; (2) a listing by state; (3) a listing by title. There is a section on taxes and tax breaks related to a solar system, one which explains how a solar system works and shows how to approximate the amount you should spend on a solar system in various parts of the country, a glossary to explain new terms, and descriptive passages to answer questions about facets of the solar energy field. The material presented was either supplied by or abstracted from information received from the companies and service organizations listed. (MHR)

**A78-42101** National Solar Energy Convention, Jadavpur University, Calcutta, India, November 29-December 1, 1976, Proceedings. Convention sponsored by the Solar Energy Society of India. Edited by S. Deb (Jadavpur University, Calcutta, India). Calcutta, Jadavpur University, 1977. 274 p. (For individual items see A78-42102 to A78-42168)

Solar energy research in India is examined. Most of the papers are concerned with equipment and techniques and are listed under the following headings: solar concentrator, photovoltaics, thermoelectric, photo, and biochemical conversion, instrumentation and environment, solar heating, solar collector, and solar distillation and cooling. Future solar energy use and costs are estimated. Industrial, domestic, and agricultural applications of solar energy in India are discussed; topics considered include the testing of five solar cookers at Jodhpur and a commercial solar dryer for Indian conditions. Reports on research programs in some other countries are presented.

M.L.

**TJ**  
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**.R42** Report of the MIT solar energy working group. -- Cambridge, Mass. : Massachusetts Institute of Technology. Energy Laboratory., 1976.

iii, 82 p. : ill. ; 23 cm.

Supported by the MIT Cabot fund.

1. Solar energy--Congresses. 2. Solar energy. I. Massachusetts Institute of Technology. Energy Laboratory. II. Title: MIT solar energy working group report.

**A77-48910** Sharing the sun: Solar technology in the seventies; Proceedings of the Joint Conference, Winnipeg, Canada, August 15-20, 1976. Volumes 1-10. Conference sponsored by the International Solar Energy Society and Solar Energy Society of Canada. Edited by K. W. Böer (Delaware University; SES, Inc., Newark, Del.). Cape Canaveral, Fla., International Solar Energy Society, 1976. Vol. 1, 402 p.; vol. 2, 404 p.; vol. 3, 417 p.; vol. 4, 436 p.; vol. 5, 561 p.; vol. 6, 360 p.; vol. 7, 403 p.; vol. 8, 381 p.; vol. 9, 322 p.; vol. 10, 281 p. Price of ten volumes, \$250. (For individual items see A77-48911 to A77-49159)

Attention is given to the roles of international and inter-governmental agencies and ERDA in developing solar energy technologies and policies. Solar energy technology is discussed with consideration of focusing and flat plate collectors, heating and cooling methods, heat pumps, passive systems, retrofit systems, simulation studies, design methods, low, intermediate, and high temperature thermal energy systems, and ocean thermal energy. Photovoltaic conversion, solar energy materials, bioconversion, wind power, agricultural and industrial process applications, solar storage, chemical storage, and solar heating of buildings are also examined. The socio-economic, cultural, and commercial implications of solar energy are discussed.

B.J.

**TJ**  
**810**  
**.R36**

**Rankins, William H.**

The solar energy notebook / written by William H. Rankins III and David A. Wilson; photography by Faris A. Ashkar. -- Black Mountain, N. C. : Lorien House, c1976.

56 p.

1. Solar energy--Handbooks, manuals, etc.  
2. Solar heating--Handbooks, manuals, etc.  
I. Wilson, David A. II. Title.

**TJ**  
**810**  
**.W54**  
**1977**

**Williams, James Richard, 1941-**

Solar energy : technology and applications / J. Richard Williams. -- rev. ed. -- Ann Arbor : Ann Arbor Science Publishers, c1977.

176 p. : ill. (plates) ; 24 cm.  
ISBN 0-250-40167-3

1. Solar energy. I. Title.

## WHO'S TO OWN THE SUN?

Ken Bossong.

Chemtech, Nov. 1977, p. 676-678.

As energy from the sun slowly inches forward to replace declining fossil fuels, the nation's privately-owned utilities are quickly buying their way into the solar market. Few city, state, or federal agencies have yet confronted the issue, but acquisition of solar patents, desert lands, and government research contracts by these utilities raises the questions: "Who will own the sun?" and "Is solar energy to be a public resource or another Wall Street commodity to be purchased and sold?"

**A79-33984** Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1 - Solar energy 1. Conference sponsored by the U.S. Department of Energy and University of Miami. Edited by T. N. Veziroglu (Miami, University, Coral Gables, Fla.). Washington, D.C., Hemisphere Publishing Corp., 1978. 554 p. Price of eleven volumes, \$495. (For individual items see A79-33985 to A79-34001)

Consideration is given to methods for measuring insulation, to flat plate collectors, and to concentrating collectors. Papers are presented on such particular topics as a solar radiation summary for Hawaii, the thermal performance of open-flow liquid solar collectors, a combination of solar direct electric conversion concentrators and heat collector system, and heliostat survivability and structural stability for wind loading. B.J.

**A79-34002** Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 2 - Solar energy 2. Conference sponsored by the U.S. Department of Energy and University of Miami. Edited by T. N. Veziroglu (Miami, University, Coral Gables, Fla.). Washington, D.C., Hemisphere Publishing Corp., 1978. 495 p. Price of eleven volumes, \$495. (For individual items see A79-34003 to A79-34021)

Solar energy conversion and utilization are discussed with reference to storage and heat transfer techniques, heating and cooling, building applications, and industrial applications. Papers are presented on such particular topics as the transient analysis and optimization of an extended surface thermal storage unit which uses a phase change material, a liquid sorbent solar air conditioner, and the development of microprocessor-based control and instrumentation subsystems for solar energy applications. B.J.

**A79-34022** Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3 - Solar Energy 3. Conference sponsored by the U.S. Department of Energy and University of Miami. Edited by T. N. Veziroglu (Miami, University, Coral Gables, Fla.). Washington, D.C., Hemisphere Publishing Corp., 1978. 475 p. Price of eleven volumes, \$495. (For individual items see A79-34023 to A79-34035)

Consideration is given to solar-electric power generation techniques, to rural and agricultural applications of solar energy, and to solar energy economics and planning. Particular papers are presented on such topics as the construction of satellite solar power stations from nonterrestrial materials, solar powered irrigation systems, and the economic prospects of solar energy for industrial process heat. B.J.

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1977

**International Solar Energy Society.**  
Proceedings of the 1977 annual meeting. Editors: Charles Beach (and) Edward Fordyce. Cape Canaveral, Fla., 1977.

Sections 1-13, 371 p.; Sections 14-25, 363 p.; Sections 26-38, 360 p. Price of three volumes, members, \$25; nonmembers, \$45.

The use of solar collectors for heating and cooling systems is discussed, with attention given to liquid- and air-heating collectors, the design, orientation and selection of materials for collectors, as well as to heat pumps, passive systems, controls and instrumentation, and window walls. Topics of the papers include a National Bureau of Standards facility for rating flat-plate air heaters, polymer films for the inner glazing of flat-plate collectors, the reevaluation of solar panels in use for twenty years, heat-transfer fluids, the design of absorbers, a solar-powered desiccant air conditioner, computer programs as design tools in developing economical solar heating systems, maintenance costs of solar air heating systems, the effect of local variations in cloud cover on collector efficiency, and fluid control in flat-plate and evacuated tube collectors. J.M.B.

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.P4P

**Perspectives on the energy crisis : technical, regulatory, environmental, economic, prospective. / advisory editors, Howard Gordon, Roy Meador. — Ann Arbor, Mich. : Ann Arbor Science Publishers, c1977.**

2 v. : ill. ; 29 cm.

**SOLAR ENERGY** . . . . . 171  
(By Laurent Hodges and John Neff, A Report from the Iowa Energy Policy Council, June 1976)

The sun, our constant thermonuclear furnace, is the subject of this conscientious report. A selective bibliography supplements sections on methods of using solar thermal energy, with brief accounts on wind, bioconversion, and the solar economy. Practical application of these methods to conditions in Iowa is illustrated.

N78-24862/ Committee on Energy and Natural Resources (U S Senate).

**SOLAR ENERGY**

Washington GPO 1977 408 p refs Joint hearing before the Subcomm. on Energy Production and Supply and the Subcomm. on Energy Res. and Development of the Comm. on Energy and Natural Resources and the Select Comm. on Small Business, 95th Congr., 1st Sess., 1 Jun. 1977 (GPO-94-910; Publ-95-65) Avail: Subcomm. on Energy Production and Supply

Testimony was presented to provide important perspectives on solar energy, particularly as related to small businesses. Means of encouraging optimum commercial development of all the alternative energy industries were discussed. Discussion centered around the opportunities and problems facing small businesses in the emerging alternative energy industries. Institutional and economic barriers to commercialization and dissemination of alternative energy products and services were outlined and the role of government in promoting commercial development was discussed. P.R.A.

**TOWARD A SOLAR CIVILIZATION**

Frank von Hippel and Robert H. Williams  
The Bulletin of the Atomic Scientists  
Vol. 33, no. 8, October 1977,  
p.12-15, 56-60.

**NEW CAREER PATHS IN ENGINEERING: APPLICATIONS OF SOLAR ENERGY.**

Lloyd O. Herwig.

Mechanical Engineering, v.99, no.10, Oct.1977,  
p.50-53.

It has been demonstrated that solar systems for heating domestic hot water and building and greenhouse space are now economically practical, particularly where the alternative is electric resistance heating. Other applications with large potential for nearer-term economic viability include solar cooling, industrial process heat, wind electric, and fuels from biomass systems.

CU-142,793

ILLUSTRATED SOLAR ENERGY GUIDE. 23p. 1977.

Horizon Industries,  
North Hollywood, Calif.

Power sources, Solar

Solar collectors

Power sources, Solar - Heating & cooling

**SOLAR ENERGY AND CONGRESS.**

William L. R. Rice.

Solar Energy.

Vol. 19 no. 6

1977

p.631-641.

Abstract--The United States Congress has given strong support to the Federal solar energy program. The President's budget request for Fiscal Year 1977 was \$162.5 million for solar energy. This was increased by Congress to \$200.4 million in the appropriations bill signed by the President on 12 July 1976. The Fiscal Year 1977 budget process for solar energy was unprecedented. Authorization hearings focused on internal budgets that were never submitted to Congress. The Executive budget process was examined in detail by Congress. And Congress acted upon the appropriation for solar energy before it considered the authorization. Based on practices established with the former Atomic Energy Commission, Congressional oversight committees were given access to the internal budget data of the Energy Research and Development Administration (ERDA). This permitted the assessment of budgets proposed by ERDA to the Office of Management and Budget vs those approved by OMB for incorporation in the President's budget to Congress. This opened to Congressional review the relative viewpoints of OMB and ERDA on funding of energy programs and resulted in the Congressional decision to fund solar R&D at levels which could be profitably utilized by the ERDA scientists. While future solar budgets may be expected to increase, it is likely they will do so at a more moderate pace than the exponential growth rate of the past three fiscal years. Other Federal incentives for utilization of solar energy technologies have not evolved. Numerous bills have been introduced in Congress for low interest loans, tax credits or deductions, and other solar incentives. Sponsors of such bills have shown no desire to induce the oversight committees to schedule hearings that could lead to consideration of solar legislation by the House and Senate. Substantive activity is not expected before the 95th Congress convenes in 1977.

HEAT TRANSFER: A REVIEW OF 1976 LITERATURE.  
E.R.G. Eckert, et al.  
Int. J. Heat Mass Transfer, v.20, no.11, 1977,  
p.1097-1125.

Section on solar energy with 31 references.

The number of heat transfer related solar energy papers was approximately the same in 1976 as in the previous year. Topics of major interest among these papers include insolation, materials development, flat plate collectors, concentrating collectors, energy storage, systems studies for heating and cooling, and systems studies for central electric power generation.

THE SEVEN-PERCENT SOLUTION.  
Robert B. Aronson and Mark D. Zimmerman.

Machine Design, vol. 49, no. 13, June 9, 1977,  
page 20-21

In using solar power, the nation can opt for "blue-collar" or "white-collar" systems. The blue-collar approach, in which surfaces and fluids are heated, are coming on-stream now and will be used widely as a supplementary means of heating and cooling buildings. The white-collar approach - converting the sun's rays

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.N47  
New trends in systems analysis : international symposium, December 13-17, 1976 / Institut de Recherche d'Informatique et d'Automatique ; edited by A. Bensoussan and J. L. Lions. — New York : Springer-Verlag, 1977. vii, 550 p. : ill. — (Lecture notes in control and information sciences ; v. 21. In English and French. ISBN 0-387-08406-1  
I. System analysis--Congresses. I. Bensoussan, A. II. Lions, J. L. III. Systems Aspects of Large Scale Solar Energy Conversion J. Weingart ... p.290.....

EXPLOITATION OF SOLAR ENERGY, I.I. Sobel'man  
Soviet Physics Uspekhi, Vol. 19, no. 9, Sept. 1976, p. 758-764

The problem of transforming the energy of solar radiation into heat and electricity is reviewed. The main attention is devoted to the possibility of heating up to fairly high temperatures, ~500°C, at which modern heat engines, turbines, etc., ensure efficient transformation of heat into electricity. Schemes are examined which are based on the use of comparatively simple concentrators of solar radiation and selective collectors. It is shown that, in addition to selective coatings, selective gas collectors are of great interest. The possibility of constructing large solar power stations is considered. At the end of the review, approximate estimates are given of the possible cost of a solar power station and the prospects for increasing the competitiveness of solar energy are discussed.

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551  
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1976  
Australian Conference on Electrochemistry,  
4th, Flinders University of South Australia,  
1976,  
Trends in electrochemistry ... c1977.  
(Card 3)  
ISBN 0-306-30990-4.  
1. Electrochemistry--Congresses.

Electrochemistry in the Solar Economy . . . . . 51  
A.J. APPLEBY

## SOLAR - RESOURCES AND AVAILABILITY

**THE AVERAGE DISTRIBUTION OF SOLAR RADIATION--CORRELATIONS BETWEEN DIFFUSE AND HEMISPHERICAL AND BETWEEN DAILY AND HOURLY INSOLATION VALUES**, by Manuel Collares-Pereira and Ari Rabl, *Solar Energy*, vol. 22, no. 2, 1979, p.155-165.

**Abstract**—The correlations of Hottel, Whillier, Liu and Jordan between diffuse and hemispherical, and between instantaneous (hourly) values and daily totals of solar radiation are recalibrated against pyrheliometer data for five stations in the U.S. The validity of the Liu and Jordan approach is confirmed, and numerical inaccuracies of the original correlations are found to arise from three factors: (i) reliance on uncorrected measurements of diffuse insolation with pyranometer plus shade ring, (ii) use of a single value of extraterrestrial insolation for a whole month, and (iii) neglect of seasonal variations in the diffuse/hemispherical ratio. The new correlation for the daily total ratio of diffuse over hemispherical insolation agrees with results reported for India, Israel and Canada which included the shade ring correction. This suggests that latitude independence is a good approximation. The new correlations imply that the diffuse component is significantly larger than that predicted by the original formulas of Liu and Jordan. Analytical expressions are presented the parameters of which are obtained by a least squares fit to the data. The resulting formulas provide a complete description of the long term average insolation incident on surfaces of arbitrary orientation; the only meteorological input is the long term average daily total of hemispherical insolation on the horizontal surface. Comparison between model and data shows an accuracy better than 3 per cent for the long term average insolation available to solar collectors, both fixed and tracking. The model provides a framework for optimal matching between solar radiation and ideal concentrators (based on the principle of phase space conservation). In addition to computing radiation availability for solar collectors, the model can be used for calculating heating and cooling loads of buildings.

**STATISTICAL STUDY OF SOLAR RADIATION INFORMATION IN AN EQUATORIAL REGION (SINGAPORE)**, by T.N. Goh, *Solar Energy*, vol. 22, no. 2, 1979, p.105-113.

**Abstract**—Results of regression analysis relating total solar radiation with common meteorological factors, based on data from Singapore, are summarized. The regression coefficients are found to be unstable over different periods of time, producing poor radiation estimates. A set of useful statistical properties of measured radiation data is next presented, showing the expected number of days in a year and in a given month of the year in which daily total radiation falls within a given range of values, and also the frequencies of occurrence of periods of successive days in which radiation is below specified values. Probabilistic limits of figures are also given to enable designers and users of solar energy utilization systems to perform calculations based on ranges of possible values, rather than point estimates, of amounts of expected radiation.

**SOLAR ENERGY ABROAD: PREDICTIONS FOR THE FUTURE, STATE OF THE ART, TECHNICAL-ECONOMIC POSSIBILITIES** Yu. N. Malevskii, B. B. Tarnizhevskii and M. N. Fugenfirov

*Applied Solar Energy*, vol. 15, no. 4, 1979, pp. 69-73.

**ANALYSIS OF SYSTEMS FOR THE GENERATION OF ELECTRICITY FROM SOLAR RADIATION** William G. Pollard

*Solar Energy*, vol. 23, no. 5, 1979, pp. 379-392.

**Abstract**—The analysis developed here relates the annual electrical output of any type of solar-electric facility directly to the effective annual insolation received on its solar collectors per unit collector area. A general expression for the capacity factor of such a facility is derived through which the ratio of the actual annual electrical output to the maximum mean annual output without demand, generating and downtime reductions, and storage losses can be determined. A general expression for a solar availability factor is also obtained which measures the ratio of the maximum mean annual output of the solar facility to that of a conventional fuel-fired plant of the same installed capacity generating at full capacity continuously for a year. An expression for the fraction of the total electrical output supplied by the solar facility is also derived. The analysis takes full account of the daily and seasonal cycles of solar radiation and its intermittent stochastic character. All results are given for a unit area of solar collector and are thus independent of the size of the facility.

The capital cost of solar-electric facilities is expressed in dollars for each kWh per yr of electrical output rather than dollars per kW of installed capacity as is customary for conventional electric generating plants. This cost in turn is divided among three components: for solar-electric generation, for nonsolar auxiliary power, and for storage. A general expression is derived in terms of actual or estimated component costs, and the results for solar generation and storage are shown in Figs. 4 and 5. The choice of solar collector area and of the relative dependence on storage and auxiliary nonsolar power is also

## UTILITIES: A GROWING SOLAR PROGRAM.

Electric Power Research Institute, vol 4, no 10,  
December 1979, p. 29-30.

**N79-31810** Department of Energy, Washington, D. C. Office  
of Energy Research.

### **SOCIAL ASSESSMENT OF ON-SITE SOLAR ENERGY TECHNOLOGIES.**

Apr 1979 251 p refs

(Grant EG-77-G-01-4040)

(HCP/R-4040-02) Avail: NTIS HC A12/MF A01

The results of an assessment of the impact of on site solar energy technology upon society are presented. The assessment utilizes the methodology of social indicators. Twenty-five appropriate social descriptions provide the framework for assessing the technologies of solar space heating and cooling, solar water heating, wind energy conversion, fuelwood and photovoltaics. The report concentrates upon those areas which cause concern as these forms of solar energy realize increasing acceptance and usage by individual citizens. DOE

**32852** (SERI/PR-52-076) Review of selected solar market studies and techniques. Berliner, D.; Christmas, S.; Costello, D.; Feller, C. (Solar Energy Research Inst., Golden, CO (USA)). Oct 1978. Contract EG-77-C-01-4042. 58p. Dep. NTIS, PC A04/MF A01.

The preliminary results of a literature review of solar energy market studies in the industrial process heat, passive, solar thermal electric, photovoltaic, wind, and ocean thermal technologies are presented. Useful elements of market studies in other solar areas are described as well. The market research literature is reviewed in order to investigate techniques or approaches that may have some applicability in the context of solar markets. A preliminary plan is presented for the initiation of selected solar market studies during FY79.

**A80-23221** Onsite solar energy systems - Economics and system design. H. C. Kelly (Office of Technology Assessment, Washington, D.C.). In: Advances in energy systems and technology. Volume 2. (A80-23218 08-44) New York, Academic Press, Inc., 1979, p. 101-178. 91 refs.

On-site solar energy systems are discussed with reference to scale considerations, costs and ownership, costs of competing energy, risk, and net costs to society. A method for evaluating the quantitative worth of solar energy is presented, and attention is given to the design of solar equipment and to basic issues in solar design. B.J.

**SOLAR RESEARCH AROUND THE WORLD: ISRAEL**, by G. Grossman  
A. Shitzer and Y. Zvirin.

ASHRAE Journal, vol. 21, no. 2, February 1979, p.40-44.

Work in progress on solar energy-related topics may be classified into the following categories: (a) research and development of both basic and applied topics, (b) design, construction and testing of solar operated systems, and (c) testing and evaluation of solar operated equipment and systems for industry. Special emphasis is placed on research, development and evaluation of complete systems with component development performed only as required for system operation. The various projects currently in progress are outlined in these pages.

**N80-14547** Midwest Research Inst., Golden, Colo.

### **A REVIEW OF THE ECONOMICS OF SELECTED PASSIVE AND HYBRID SYSTEMS**

Deborah L. Buchanan Jan. 1979 27 p refs

(Contract EG-77-C-01-4042)

(SERI/TP-61-144) Avail: NTIS HC A03/MF A01

Performance and economic information on passive and hybrid systems were compiled as part of solar commercial readiness activities. The results of selected performance simulation and cost estimate studies are presented as well as actual cost and performance data from operating buildings. Systems representative of each major passive design concept are included: direct gain, indirect gain (thermal storage wall, thermal storage roof), and isolated gain (convective loop/thermosiphon, attached sunspace/greenhouse). Results are presented in tables structured by major design concept. Data for simulated and actual systems are presented separately. Comparison of individual system design specifications, performance, incremental solar cost, and cost of delivered energy are made by major design concept and by simulated or actual data source. In addition, results are aggregated to derive cost and performance ranges over all data sources, by design concept and by simulated or actual system. DOE

**N80-10637** Los Alamos Scientific Lab., N. Mex.

### **SELECTED RESULTS FROM THE TECHNOLOGY ASSESS- MENT OF SOLAR ENERGY PROGRAM**

Milton C. Krupka and John H. Altseimer 1979 8 p refs

Presented at AIAA Terrestrial Energy Systems Conf., Orlando, Fla., 4-6 Jun. 1979

(Contract W-7405-eng-36)

(LA-UR-79-950. Conf-790611-3)

Avail. NTIS

HC A02/MF A01

Emerging solar technologies and selected applications were studied from environmental, institutional and social viewpoints. The impacts resulting from the large scale deployment of decentralized solar technologies were assessed. Emphasis was placed upon technical characterization of the technology and the development of a representative model system for a given application upon which an environmental analysis could be made. DOE

A79-38187 # Selected results from the technology assessment of solar energy program. M. C. Krupka and J. H. Altseimer (California University, Los Alamos, N. Mex.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0984*. 9 p. 21 refs. Research sponsored by the U.S. Department of Energy.

Selected results on the environmental, institutional and social impacts of the large-scale deployment of decentralized solar technologies obtained by the Technology Assessment of Solar Energy program of the Department of Energy are presented. The first phase of the program is almost complete and consisted of characterizing different solar technologies and quantifying the indirect residuals of solar energy acquisition. A second phase will assess selected environmental, social, health and safety aspects of solar technology utilization. Study results for a model residential photovoltaic system are presented as an example. While the operating environmental impacts of solar technologies are considered to be small, with the possible exception of residuals derived from a battery energy storage subsystem, indirect impacts may be considerable. For a photovoltaic silicon solar cell technology, solar cell fabrication and metallurgical grade silicon production technologies have been found to cause extensive pollution in some cases. A.L.W.

- TK Intersociety Energy Conversion Engineering  
2896 Conference, 14th, Boston, 1979.  
.155 Proceedings of the 14th Intersociety  
1979 Energy Conversion Engineering Conference,  
Boston, Massachusetts, August 5-10, 1979.  
-- Washington, D. C. : American Chemical  
Society, c1979.  
2 v. (xviii, 2078, 294 p.) : ill.  
"IEEE 79CH1477-9 Energy."  
Includes bibliographical references and  
index.  
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Predicting Solar Energy Fluxes in Polluted  
Urban Areas, T.R. Galloway ..... 32

A79-44239 Turning to the sun for power. J. Hopkinson.  
*EPRI Journal*, vol. 4, June 1979, p. 18-21.

Problems of supply and collection in solar-thermal conversion are discussed. A solar thermal power plant concept is described which incorporates a closed Brayton-cycle (gas turbine) system. Advantages of the Brayton cycle are its reduced need for cooling water and higher efficiency due to recycling of hot exhaust air back to the receiver. These factors increase siting flexibility and reduce land requirements, respectively. A 1-MW (th) solar receiver is described which uses air, heated from 1000 F to 1500 F, as the working fluid. Also studied is an open Brayton cycle central receiver concept which heats air to 2000 F to achieve higher thermal efficiency. Finally, a solar-fossil hybrid turbine is described, as a means of back-up generation to ensure a constant power supply. M.E.P.

## Standardization in Solar Energy by G.T. Pytlinski

ASTM Standardization News, Vol. 7, No. 8, August 1979,  
p.9-12

In the current climate of energy shortages and soaring fuel costs, solar energy is receiving more and more attention from industry, the government, and the consuming public as an alternative to fossil fuels. And that puts the spotlight on solar standardization, as a prerequisite for the orderly development of the mushrooming solar market.

## CONSTRUCTION COSTS IN COMMERCIAL SOLAR.

Energy Engineering, vol 77, no 1, December 1979/Jan.  
1980, p. 11-32.

**ABSTRACT:** Detailed construction cost data for 14 commercial Projects in the National Solar Demonstration Program have been collected and reported as part of the National Solar Data Program. The data were collected during visits to the sites, through discussions with key personnel and review of DOE vouchers. This paper summarizes the cost data collected to date, compares the costs of different systems, and presents an analysis

of factors that may have an impact on solar system and subsystem construction costs. The cost factors discussed include the following:

- System type
- New versus retrofit systems
- Economies of scale
- Collector mounting
- Multi-function support structures
- Storage type and size
- Control complexity

The impact of a variety of these cost factors is demonstrated by postulating changes in the configuration of an existing system and estimating the cost reductions

**RENEWABLE ENERGY PROSPECTS. (Special issue).**  
**(Proceedings of a Conference on Non-Fossil Fuel**  
**and Non-Nuclear Fuel Energy Strategies.**  
**Held in Honolulu, Hawaii, Jan.9-12,1979.**  
**Sponsored by the United Nations University at**  
**Tokyo, Japan). Wilfrid Bach, et al, eds.**

- Hayes, D.: Solar possibilities ..... 761  
 Weingart, J. M.: Global aspects of sunlight as a major energy source ..... 775

**United Nations U.,**  
**Tokyo, Japan**

**A79-47944** Toward optimal control of solar energy systems. S. F. McCormick (Colorado State University, Fort Collins, Colo.). In: 1978 Conference on Decision and Control, 17th, San Diego, Calif., January 10-12, 1979, Proceedings. (A79-47930 21-63) New York, Institute of Electrical and Electronics Engineers, Inc., 1979, p. 193-196, 5 refs.

The paper focuses on a project designed to investigate the feasibility of a microprocessor-based control device for use in domestic solar energy systems. The underlying objective is to emphasize that fundamental simplicity both in design and implementation is a key to reducing the software difficulties and succeeding in the development of effective devices for process control. The development goals of the controller considered include cost effectiveness, stability, flexibility, adaptability and weather predictability. Although these characteristics are achieved at the expense of additional system hardware requirements, the balance appears to be well in favor of the controller system discussed.  
 S.D.

**N79-33803/** Community Services Administration, Washington, D. C.

**SOLAR ENERGY POLICY**

Jan. 1979 57 p refs

(PB-296193/6; CSA/NF-03; CSA/Pam-6143-10) Avail: NTIS  
 HC A04/MF A01 CSCL 13A

The energy-related problems of the poor and near-poor are described. Including their lack of funds with which to pay sharply increasing utility bills, the decline in health and deterioration in living conditions when increasing numbers of families have to choose between food and energy, and in the cases of the elderly and the handicapped, a challenge to survival which they face. The Community Service Administration's energy-related policy goals are detailed.  
 GRA

**A79-51851\*** Toward the renewables - A natural gas/solar energy transition strategy. J. A. Hanson (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.) and W. J. D. Escher (Escher: Foster Technology Associates, Inc., St. Johns, Mich.). In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 796-799, 6 refs.

The inevitability of an energy transition from today's non-renewable fossil base toward a renewable energy base is considered from the viewpoint of the need for a national transition strategy. Then, one such strategy is offered. Its technological building blocks are described in terms of both energy use and energy supply. The strategy itself is then sketched at four points in its implementation; (1) initiation, (2) early transition, (3) late transition, and (4) completion. The transition is assumed to evolve from a heavily natural gas-dependent energy economy. It then proceeds through its transition toward a balanced, hybrid energy system consisting of both centralized and dispersed energy supply technologies supplying hydrogen and electricity from solar energy. Related institutional, environmental and economic factors are examined briefly. (Author)

**N80-18839/** Midwest Research Inst., Golden, Colo Solar Energy Research Inst.

**ROLE OF THE GOVERNMENT IN THE DEVELOPMENT OF SOLAR ENERGY**

M. D. Yokell 1979 29 p refs Presented at the Ann. Meeting Assoc. for the Advan. of Sci., Houston, Tex., 4 Jan. 1979 (Contract EG-77-C-01-4042)

(SERI/TP-52-138; CONF-790122-3) Avail: NTIS  
 HC A03/MF A01

The economic rationale for a Federal solar energy subsidy program, the type of program required, and methods for determining the proper funding level for each program are discussed. An introduction offers a brief description of solar technologies. A summary of the current Federal solar subsidy program is also provided.  
 DOE

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**Eggers-Lura, A.**

**Solar energy in developing countries : an overview and buyers guide for solar scientists and engineers / A. Eggers-Lura. -- Oxford ; New York : Pergamon Press, 1979.**

vii, 205 p. -- (Pergamon European heliostudies ; v. 1)

Includes index.

ISBN 0-02-023253-1

1. Under-Solar energy.

developed areas--

I. Title. II. Series.  
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Solar Availability for Winter Space Heating: An Analysis of SOLMET Data, 1953-1975. by J.G. Asbury, C. Maslowski & R.O. Mueller

Science, Vol. 206, No. 4419, 9 November 1979, p. 679-681

*Abstract. Solar availability for space heating on coldest-weather days has been determined from an analysis of SOLMET data tapes. The tapes contain hourly readings of insolation and ambient temperature over the period from 1953 through 1975. Scatter diagrams of insolation versus heating degree-days, compiled on a daily basis, indicate a wide variation in the insolation level, even during coldest-weather periods. For all but one of the eight sites studied, the peak-day backup energy requirement of the solar system was in excess of 85 percent of the peak-day energy requirement of the conventional (nonsolar) heating system.*

**NSO-18532/** Argonne National Lab., Ill. Energy and Environmental Systems Div.

**SOLAR AVAILABILITY FOR WINTER SPACE HEATING: AN ANALYSIS OF THE CALENDAR PERIOD 1953-1975**

J. G. Asbury, C. Maslowski, and R. O. Mueller Apr 1979  
20 p refs

(Contract W-31-109-eng-38)

(ANL/SPG-14) Avail NTIS HC A02/MF A01

Data tapes for eight US sites containing hourly readings of insolation and ambient temperature for the period 1953-1975 were analyzed. Scatter diagrams of insolation versus heating degree-days, compiled on a daily basis, indicate a wide variation in insolation levels, even during periods of coldest weather. For seven of the eight sites, the peak-day backup energy required by a solar space heating system exceeded 85 percent of the peak-day energy requirement of a conventional (nonsolar) heating system. The cities considered are Albuquerque (NM), Bismark (ND), Boston (MA), Caribou (ME), Columbia (MO), Madison (WI), Seattle (WA), and Sterling (VA). DOE

**A80-18573 #** Optimization and comparison strategies for solar energy systems. R. C. Estes and W. Kahan (Singer Corporate Research and Development Laboratory, Fairfield, N.J.). *American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Dec. 2-7, 1979, Paper 79-WA/Sol-26.* 13 p. 8 refs. Members, \$1.50; nonmembers, \$3.00. Contract No. EG-77-C-03-1467.

An analytical model of several simple, generic solar energy systems, with and without heat pumps is described. The model is augmented by marginal analysis to configure the components of each system type for an economic optimum and consequently, for maximum marketability. This model is to be used as a first-cut means of identifying the combinations of ranges of system component parameters and general geographic regions for which each generic configuration is most marketable. Assessment of marketability includes the following considerations: the size of the capital investment, the operating cost savings relative to alternative systems, future cost of energy, and cost of money. The following six systems types are optimized (where appropriate) and compared: (1) an all electric resistance heating system, (2) a stand-alone heat pump system, (3) a stand-alone solar energy system, (4) a series solar assisted heat pump (SAHP) system, (5) a parallel SAHP system, and (6) a dual source SAHP system. (Author)

**A80-21937** Storage of solar energy. T. B. Taylor (Princeton University, Princeton, N.J.). *Indian Academy of Sciences, Proceedings, Section C: Engineering Sciences*, vol. C 2, Sept. 1979, p. 319-330. 8 refs. Research supported by the Rockefeller Foundation.

A framework is presented for identifying appropriate systems for storage of electrical, mechanical, chemical, and thermal energy in solar energy supply systems. Classification categories include the nature of the supply system's setting; the type of energy supplied; the type of solar energy collection system used (including 'indirect' solar energy, such as wind and hydropower); the type of energy stored; and some other characteristics of the storage system. A global insolation summary is used to exhibit the diversity of requirements for solar energy storage in different settings. Comments are then made on the need and opportunities for 24 hr storage of electrical energy in batteries; backup systems that use stored chemical fuel derived from solar energy; storage of intermediate temperature heat as heat of hydration of compounds such as sulfuric acid; annual storage of low temperature heat in fresh water ponds or aquifers; and annual storage of ice produced in places with cold winters. Arguments are presented for using a systems approach to the selection of solar energy storage methods appropriate for use in specific types of settings. (Author)

**N80-13849/ Midwest Research Inst., Golden, Colo.  
REVIEW OF THE ENVIRONMENT EFFECTS AND BENEFITS  
OF SELECTED SOLAR ENERGY TECHNOLOGIES**

Kathryn A. Lawrence May 1979 18 p refs

(Contract EG-77-C-01-4042)

(SERI/TP-53-114R) Avail: NTIS HC A02/MF A01

The environmental effects of photovoltaic cells, wind energy conversion (WEC), and the solar thermal central receiver are reviewed and summarized. The solar energy technologies are assumed to be deployed as centralized energy production facilities. The phase of resource extraction and component production is the most environmentally hazardous. Impacts of plant construction will be somewhat site specific but should approximate impacts associated with any large construction activity. The operation phase is relatively environmentally benign. The WEC operation produces low level noise pollution and presents minimal hazards to flying species. Solar thermal facilities equipped with wet cooling towers may affect local air quality via cooling tower drift. In addition, large installations of each option may alter local microclimate. Decommission of WEC, solar thermal, and photovoltaic facilities should prevent no environmental hazards, although disposal of CdS or GaAs cells will require care. DOE

**A80-17131 Global aspects of sunlight as a major energy source.** J. M. Weingart (California, University, Berkeley, Calif.), (United Nations University, East-West Center, International Institute for Applied Systems Analysis, and University of Hawaii, Conference on Non-Fossil Fuel and Non-Nuclear Fuel Energy Strategies, Honolulu, Hawaii, Jan. 9-12, 1979.) *Energy* (UK), vol. 4, Oct. 1979, p. 775-798, 65 refs. Research supported by the Ford Foundation, International Institute for Applied Systems Analysis, Electric Power Research Institute, and University of California.

To achieve and sustain a decent livable world for all is a central goal for human society. While an abundant supply of energy is not in itself a determinant of such a world, it is nevertheless essential. A careful inquiry suggests that sunlight could eventually be the primary and even exclusive source of heat, electricity and synthetic fuels for the entire world, continuously and eternally on a scale (upwards of 100 TW) generally regarded possible only with fusion or with fission via the fast breeder. This could be achieved through a global network of solar conversion facilities coupled with appropriate energy transport and storage systems, and appears to be possible within acceptable constraints on energy payback time, materials and water resources, capital investment, and available suitable land. (Author)

**TECHNICAL NOTE: UNITS AND SYMBOLS IN SOLAR ENERGY.**

W. A. Beckman, et al.

*Solar Energy*, Vol. 21, No. 1, 1978, p. 65-68.

First, the application of S.I. units to some common solar energy quantities is discussed and some interpretations made for particular cases. Then, a list of names, symbols and units is recommended.

**N80-14518/ Midwest Research Inst., Golden, Colo.  
APPLICATION OF DIFFUSION RESEARCH TO SOLAR  
ENERGY POLICY ISSUES**

J. D. Roessner Mar 1979 35 p refs

(Contract EG-77-C-01-4042)

(SERI/TR-51-194) Avail: NTIS HC A03/MF A01

Two types of information requirements that appear to be basic to DOE solar energy policy decisions are examined: (1) how can the future market success of solar energy technologies be estimated, and (2) what factors influence the adoption of solar energy technologies, and what specific programs could promote solar energy adoption most effectively? The ability of a body of research, referred to here as diffusion research, to supply information that could partially satisfy these requirements is assessed. The strengths and limitations of current knowledge about the diffusion of innovations are summarized, the applicability of both existing knowledge and the diffusion approach to the identified solar energy policy issues are discussed, and ways are suggested in which diffusion approaches can be modified and existing knowledge employed to meet short and long term goals of DOE. DOE

**APERTURE EFFECTS ON ATMOSPHERIC TURBIDITY MEASUREMENTS,**  
by G. M. Shah.

*Solar Energy*, vol. 21, no. 6, 1978, p.527-530.

An attempt is made here to examine the effect of aperture geometry of the instrument on derived aerosol optical thickness in the atmosphere. This is important for comparisons of the turbidity trends over locations using instruments with different angular fields of view.

**SOLAR ENERGY FOR VILLAGE DEVELOPMENT**

Norman L. Brown and James W. Howe  
Science

Vol. 199 no. 4329 February 1978

p. 651-656

**Summary.** The National Academy of Sciences held a joint workshop with the Government of Tanzania last August on the potential of solar energy for the villages of that country. Costs of five solar technologies (mini-hydroelectric generators, wind, methane generation from organic wastes, photovoltaic cells, and flat-plate solar collectors) were compared with costs of diesel-generated electricity and with electricity from the national grid. Each of the five technologies is either now competitive with diesel or will be in a few years. Although the figures presented are not conclusive since they are derived from calculations rather than an actual test, the results are encouraging enough to warrant serious testing in Third World villages.

# ESTIMATION OF HALF-HOUR SOLAR RADIATION VALUES FROM HOURLY VALUES, by V. M. Puri.

Solar Energy, vol. 21, no. 5, 1978, p.409-414.

**Abstract**—A statistical Markovian insolation model for predicting the time-sequence of half-hour solar radiation values on a horizontal surface which uses the hourly insolation values is developed. The hourly transition density function, governing the diurnal evolution of the hourly solar radiation values, is used for obtaining the half-hour transition density function. A transition density function is a measure of the probability of the event at the next immediate hour of interest when the event at the present hour is given. The estimation of half-hour transition density function is done through the fundamental decomposition theorem for the density function. This assumes a set of well defined intermediate states. As a first approximation, the half-hour transition density function is assumed to be temporally stationary. Furthermore, it is assumed that the cumulative probability distribution functions of the normalised initial hour solar radiation value and the normalised initial half hour solar radiation values are not significantly different, the hourly, or half-hourly solar flux values are normalised by the corresponding extraterrestrial solar flux values. The validity of these assumptions is established through the successful time-sequence predictions of the half-hour insolation values. The time-sequence aspect of solar radiation values is proved by comparing the predicted joint cumulative distribution functions for several successive normalised half hour values, with the corresponding distribution function for the recorded values. In order to prove that the predicted and actual distribution functions are from the same set, the non-parametric statistical test proposed by Kolmogorov and Smirnov has been used.

## NSO-10825/ Battelle Pacific Northwest Labs., Richland, Wash. METHODOLOGY FOR IDENTIFYING MATERIALS CONSTRAINTS TO IMPLEMENTATION OF SOLAR ENERGY TECHNOLOGIES

J. W. Litchfield, R. L. Watts, W. E. Gurwell, J. N. Hartley, and C. H. Bloomster Jul 1978 91 p refs (Contract EY-76-C-06-1830)

(PNL-2711) Avail: NTIS HC A05/MF A01

A materials assessment methodology for identifying specific critical material requirements that could hinder the implementation of solar energy was developed and demonstrated. The methodology involves an initial screening process, followed by a more detailed materials assessment. The detailed assessment considers such materials concerns and constraints as process and production constraints, reserve and resource limitations, lack of alternative supply sources, geopolitical problems, environmental and energy concerns, time constraints, and economic constraints. Data for 55 bulk and 53 raw materials required in the example photovoltaic systems are available on the data base. Engineering and bulk material requirements were defined for one photovoltaic system, thirteen photovoltaic cells, ten solar heating and cooling systems, and two agricultural and industrial process heat systems.

DOE

Environmental Science and Technology  
v 12, no. 12, p 1242-1244

Nov.  
1978

**A 1990'S FORECAST: BRIGHT SUNSHINE** (A close look at funding and technology needs for the next decade's solar energy push).

Solar energy

# THE FRACTION OF SOLAR ENERGY AVAILABLE FOR DIRECT CONVERSION PROCESS.

M.D. Archer

Solar Ener., v.20, no.2, 1978, p.167-169.

Trivich and Flynn[1] appear to have been the first to point out that direct converters of solar energy can transduce only a calculable fraction of incident broad band light to useful work, because they can only make use of photons with more energy than a threshold value  $e_g$ . In a photovoltaic converter,  $e_g$  is the semiconductor band gap. In an energy-storing photochemical reaction,  $e_g$  is the energy of the first excited singlet state of the light-absorbing molecule. Photons of energy  $e < e_g$  are not absorbed by the converter, or, if they are, they are not convertible to useful work. Photons of energy  $e > e_g$  are also not wholly available, because vibrational relaxation occurs in the electronically excited state before the primary electron transfer or other photochemical reaction can take place. The fraction  $(e - e_g)/e$  of the photonic energy is therefore dissipated as heat, and only the fraction  $e/e_g$  is available for conversion to useful work (electrical energy or chemical free energy).

**A79-31418** Report on a survey of operational solar systems. D. Lorrimer (Raymond Moriyama, Architects and Planners, Toronto, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 9 p.

During the winter and spring of 1978, a study was undertaken for the National Research Council to survey operational solar systems in North America - especially those operating in climates similar to Canada's. The purpose of the survey was to learn from the experiences gained from these systems and to report on any problems that may have developed in order to identify areas that require further research. Although the collector component of the systems received the most attention, other parts of the systems were also considered. The survey included a literature review, a mailed questionnaire programme and site visits to over 60 installations. This paper will summarize the findings of the survey. (Author)

## THE SOLAR TIMETABLE

Environment, vol. 20, no. 6, July/August 1978, p. 6-13 (Continued on page 38)

By the year 2025 renewable energy sources could provide five-sixths of the world's energy budget. The steps we would have to take and the extent of the commitment we would have to make to achieve this goal are outlined by the organizer of Sun Day.

On the nature and distribution of solar radiation ---  
Insolation and earth atmosphere effects  
Watt Engineering Ltd., Cedaredge, Colo. AVAIL. NTIS  
HC A12/NF A01

/\*ATMOSPHERIC ATTENUATION/\*EARTH  
ATMOSPHERE/\*INSOLATION/\*RADIATION DISTRIBUTION/\*SOLAR  
RADIATION/ ATMOSPHERIC MOISTURE/ ATMOSPHERIC TURBULENCE/  
CLOUD COVER/ SOLAR FLUX DENSITY/ SOLAR TERRESTRIAL  
INTERACTIONS  
ABA:ERA

ABS: Radiation from the sun and the effects of the  
earth's atmosphere on the solar energy available over the  
U.S. are examined. A model is developed which permits  
calculation of average values of direct normal insolation,  
diffuse insolation, and total horizontal (global)  
insolation. The inputs required are atmospheric moisture,  
turbidity, and cloud cover or percent sunshine. Insolation  
maps giving seasonal trends and annual average daily energy  
density values are presented for the direct normal term,  
the diffuse horizontal term, and the total horizontal  
(global) term. Model outputs and observed values are  
compared.

#### SWEDEN STRIDES TOWARDS A SOLAR SOCIETY.

Gordon Taylor.

New Scientist, Vol. 79, No. 1117, August 24,  
1978, p. 550-552.

**Gordon Taylor**  
is a thermal  
engineering consultant  
and an active member  
of the International  
Solar Energy Society

Last year the Swedish government-  
funded Secretariat for Future  
Studies published a report\* which  
described how the country's energy  
supply could be based entirely on  
domestic and renewable—solar—  
energy sources by 2015. The main

features of the report are that, even with enhanced con-  
servation practices, the total energy supplied will be some  
37 per cent more than in 1975. It is, therefore, a rational  
rather than a crisis or hairshirt plan. Indeed, it is just  
because the plan is based on ambient energy, which is both  
renewable and with negligible ecological consequences,  
that such an increased energy supply can be contemplated  
happily. About 12 per cent would be direct solar heating,  
62 per cent would be from biomass-yielding solid, liquid  
and gaseous fuels—and some 26 per cent solar-generated  
electricity, including hydroelectricity.

#### USE OF PLASTICS IN SOLAR ENERGY APPLICATIONS, by A. Blaga.

Solar Energy, vol. 21, no. 4, 1978, p. 331-338.

**Abstract**—A discussion of the state-of-the-art on the use of plastic materials in solar energy applications is presented, with particular emphasis on their suitability and durability. The availability of plastics in many types and shapes (including sheeting material, films and foams) accounts for the wide range of current and potential applications in solar energy installations. Consequently, actual and potential uses of plastics include: covers (glazings), honeycomb structures and housings for flat-plate collectors; reflecting surfaces, optical lenses, shells, structural and support members for solar concentrating collectors; and insulation and piping. The plastics that have been discussed in this article in relation to their use as components in solar installations include poly(methyl methacrylate) (PMMA), polycarbonate (PC), glass fiber-reinforced polyester (GRP), poly(vinyl fluoride) (PVF), fluorinated ethylene-propylene (FEP) copolymer, poly(ethylene terephthalate) (PET) and various foamed plastics.

The aging behaviour of most of these plastics has been widely studied for normal outdoor exposure and in artificial weathering devices, and are thus briefly described here. Very little information is available, however, regarding their short-term performance under actual service conditions in solar energy installations; none has been reported on their long-term durability.

Plastics have various degrees of flammability and therefore special care should be taken by using materials with adequate fire resistance and/or appropriate design in applications where a fire hazard may exist.

#### ANALYSIS OF SOLAR RADIATION MEASUREMENTS AT ATHENS OBSERVATORY AND ESTIMATES OF SOLAR RADIATION IN GREECE

by Bas. D. Katsoulis and Const. E. Papachristopoulos

Solar Energy, vol. 21, no. 3, 1978, p. 217-226

**Abstract**—In this paper measurements of Global (G) Solar Radiation on a horizontal surface at Athens during the 16 yr period 1960-75 are analysed. Mean annual, monthly and daily totals, the diurnal variation, frequency distribution of daily totals, frequency of occurrence of daily totals of Global Radiation less than 8.5, 17, and 34 MJ/m<sup>2</sup> for 2, 3, 4 and 5 successive days are computed and discussed.

Direct Solar Radiation at normal incidence (I) is computed and analysed in a similar manner to that of Global Radiation, for the same period. Components of direct radiation of normal incidence have been computed from spot value observations at times when sky conditions permitted.

Annual values of global radiation were estimated from sunshine measurements (1960-73) widely distributed throughout Greece. It is considered that this analysis of measurements should closely represent the radiation climatology of Greece.

#### COMPUTATION OF IR SKY TEMPERATURE AND COMPARISON WITH SURFACE TEMPERATURE, by Marshall A. Atwater and

John T. Ball

Solar Energy, vol. 21, no. 3, 1978, p. 211-216

**Abstract**—The effects of atmospheric IR radiation must be accounted for in energy budget computations of solar collectors. IR radiation is often parameterized by determining an equivalent sky temperature dependent on surface temperature. Hourly values of IR radiation were computed at eleven stations in the United States in 1971 and 1972 and the equivalent sky temperature obtained. The model used for these computations was verified by comparison with special observations in the Lake Ontario region taken during the International Field Year of the Great Lakes (IFYGL) in 1972. Differences between surface temperature and sky temperature ranged between 5 and 20°C and are a complex function of season (specifically of cloudiness, humidity, and surface temperature) and geographical location.

TECHNICAL NOTE, ANNUAL AVAILABLE RADIATION FOR FIXED AND TRACKING COLLECTORS, by William C. Dickinson  
Solar Energy, vol. 21, no. 3, 1978, p. 249-251

Recently, Neville[1] published maximum possible values of annual direct beam radiation for several non-tracking and tracking collector geometries in common use. These values were calculated assuming perfect (cloudless) weather and accounting for the attenuation of direct radiation through the earth's air mass as a function of the angle between the normal and the solar rays. We show in this note that recently available values of direct beam, long-term average annual radiation for different collector geometries are disappointingly low in most parts of the continental U.S. and are much lower than the "ideal" values presented by Neville.

ANALYTICAL MODEL AND SIMULATION CODE FOR THE SOLAR INPUT DETERMINATION: IRRADIANCE MAPS, by G. Russo  
Solar Energy, vol. 21, no. 3, 1978, p. 201-210

Abstract—The Author's purpose is to introduce and motivate the application of simulation codes to Solar Energy Systems' engineering. An analytical model for the computation of the instantaneous and integrated values of the solar energy flux is illustrated. The correspondent simulation code, CIRRAGGIA 1, is a proper input to the simulation codes of the operating conditions of the system, SIRRAGGIA 1 and SIRRAGGIA 2, and furnishes the Solar Maps of the area under analysis on the basis of a few meteorological parameters, generally available. On the basis of the site individuation, the calculation of the daily or instantaneous values of the astronomical parameters is performed; the beam's atmospheric path is then individuated. The calculation of the attenuation of the beam due to the atmospheric absorbance and the correlation of this attenuation to meteorological parameters, easily available on a macro, meso and microclimate approximation, follow.

The calculation of all solar data necessary for the engineering of a solar system is performed. Code realization, in FORTRAN IV language, is described and possible applications are discussed. Finally the code is used for the realization of irradiance maps of two Italian areas: Torino and Trapani.

GEOMETRIC BROWNIAN DISTRIBUTION OF SOLAR RADIATION WITH AN ECONOMIC APPLICATION. SS. Hamlen, et al.  
S.S. Hamlen and W.A. Hamlen, Jr. and J.T. Tschirhart.  
Solar Energy, v. 21, 1978, p. 469-475.

Abstract—This paper presents the results of a recent model by Hamlen and Hamlen[1] which uses a distributed lag model to predict local levels of incoming solar radiation. The results indicate that the daily levels display a geometric Brownian motion. This distribution was introduced by Professor Samuelson[2] to explain the movement in stock prices over time. It modifies the more familiar arithmetic Brownian motion to eliminate the problem of negative values of the predicted stock prices with a high probability. Solar radiation, like stock prices, cannot take on negative values and requires the geometric Brownian motion. The distribution is introduced and parameters of the distribution are given for twenty-two cities in the U.S.

The results are then applied to the problem of determining economically efficient combinations of heating technologies given a solar heating system and a conventional backup system. A production function for heat is developed that results in a stochastic function with two random variables: available solar radiation and outside temperature. This, in turn, results in a chance constrained cost minimization problem.

THE ATMOSPHERIC RADIATION CLIMATE OF THAILAND, by R. H. B. Exell  
Solar Energy, vol. 21, no. 2, 1978, p. 73-77

A knowledge of downward atmospheric radiation at the earth's surface having wavelengths of the order  $4-40 \mu\text{m}$  is of fundamental importance for certain purposes such as solar collector analysis, natural air conditioning by nocturnal cooling, and agricultural studies. In a hot climate one would like to know how far it is possible to cool objects on the ground by radiation to the sky at night[1], a process governed by the intensity of downward atmospheric radiation. This radiation is difficult to measure because the instrument is at a temperature close to that of the radiation itself, and measurements are rare or nonexistent in many areas, especially in the tropics. It can, however, be calculated from routine meteorological data with an accuracy comparable with that of the measurements. The present paper reports the methods and results of such calculations made for meteorological conditions in Thailand, a country for which no data have hitherto been published.

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Radiation in the atmosphere ... c1977.  
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Includes index.

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1. Atmospheric radiation—Congresses. 2. Solar radiation—Congresses. 3. Radiative transfer—Congresses. 4. Atmosphere, Upper.—Remote sensing—Congresses. 5. Aerosols—Congresses. I. Bolle, Hans-Jürgen. II.

Present State of the World Solar Radiation Network  
T. G. Berlyand . . . . .

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## DETERMINING TYPICAL WEATHER FOR USE IN SOLAR ENERGY SIMULATIONS.

William R. Petrie & Michael McClintock

Solar Energy, Vol. 21, No. 1, 1978, p. 55-59.

**Abstract**—Predicting the performance of a solar energy system by using simulation methods requires weather data input for the locality involved. The present paper describes a method of analyzing an optional number of years of weather data for a chosen month resulting in a "typical week" which is characterized in terms of solar radiation, ambient dry bulb temperature and wind speed. The "typical week" is allowed to vary in length between 5 and 10 days in the analysis in order to enable selection of a period that best represents a given month according to specified criteria.

Verification of the method by comparative computer analysis was performed using two forms of weather data as inputs to the solar energy program "TRYNSYS". The averaging method when compared to the "typical" weather method resulted in differences of less than 7 per cent.

The use of "typical" weather appears to give results at least comparable with more established methods while at the same time providing a broad spectrum of the weather typical of an area. The use of "typical" weather can result in savings in computer time.

**A79-44796** • The engineering analysis of solar radiation. M. S. Reid, C. L. Hamilton, and O. V. Hester (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). *International Journal of Policy Analysis and Information Systems*, vol. 2, July 1978, p. 187-217. 12 refs. Contract No. NAS7-100.

A necessary precursor to construction of well-designed, efficient, and economically viable solar energy systems is the engineering analysis not only of the systems themselves but also of the solar radiation that will drive them. This paper presents the first steps in such an analysis to support the design of solar thermal power systems. A rationale for development of an integrated approach to this analysis is outlined, and elements of the approach are described. A dynamic computer simulation of a conceptual system was employed in an initial sensitivity analysis to explore how performance estimates might be affected by the precision and amount of detail in solar radiation data used as model input. A measurement program, including instrumentation, used to characterize precisely and in detail the solar resource at one location is described as is a probabilistic model derived from it, for predicting insolation as a function of time. (Author)

## DIFFUSE SOLAR RADIATION ON A HORIZONTAL SURFACE FOR A CLEAR SKY, by R. O. Buckius and R. King. Solar Energy, vol. 21, no. 6, 1978, p.503-509.

The purpose of the present work is to develop an accurate model for the diffuse or sky radiation based upon measurable optical properties of the earth's atmosphere. A closed-form solution for the radiant energy incident on a horizontal plane at the earth's surface is presented and the dependence upon climate model, air mass, and surface reflection is shown.

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## Institute of Electrical and Electronics Engineers, Region 6.

IEEE 1978 Region Six conference record :

Microprocessors Applied to Solar Data Collection . . . . 15

Randy J. Nichols, James N. Peterson  
Electrical Engineering Dept., University of Idaho  
Moscow, ID

This paper describes the design of a low-cost, portable Solar Data Collection System (SDCS). This system is built around a Motorola MC6800 microprocessor and uses an audio cassette tape recorder for long-term data storage. It is intended for use in gathering the necessary meteorological data for performance and design analysis of solar heating and cooling systems. The use of the microprocessor allows the operator to select appropriate start time, stop time, sample rate, and provides easy zero offset and gain adjustments for each channel.

The SDCS can sample, process, and store solar radiation and temperature data, unattended, for a two week period. Data is stored on audio cassette tape in blocks of up to 500 measurements. Each block contains the necessary timing information to allow proper off-line decoding which is accomplished with the aid of a general-purpose digital computer.

Section II discusses the meteorological data that is sampled and the corresponding sensors and output signals. Section III describes the considerations in a general data collection system design, and then presents the functional specifications of the SDCS. Section IV describes the hardware and software design of the actual system, and section V outlines improvements which are being incorporated in the next generation of the Solar Data Collection System.

**A78-19839** A correction procedure for separating direct and diffuse insolation on a horizontal surface. R. Bruno (Philips GmbH, Forschungslaboratorium, Aachen, West Germany). *Solar Energy*, vol. 20, no. 1, 1978, p. 97-100. 6 refs. Research supported by the Bundesministerium für Forschung und Technologie.

**A78-19840** Estimation of the monthly average of the diffuse component of total insolation on a horizontal surface. M. Iqbal (British Columbia, University, Vancouver, Canada). *Solar Energy*, vol. 20, no. 1, 1978, p. 101-105. 16 refs. Research supported by the National Research Council of Canada.

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- International Symposium-Workshop on Solar Energy, Cairo, 1978.  
International Symposium-Workshop on Solar Energy : [symposium lectures], 15-22 June 1978, Cairo, Egypt / presented by Clean Energy Research Institute, University of Miami, Florida ; sponsored by National Science Foundation ; edited by T. Nejat Veziroglu, Homer W. Wiser. -- [s.l.:s.n.,

PROPERTIES AND MEASUREMENT OF SOLAR RADIATION  
A. A. M. Sayigh, University of Riyadh, Riyadh, Saudi Arabia

POSSIBILITIES FOR SOLAR ENERGY UTILIZATION IN EGYPT  
I. A. Sakr, Head of Solar Energy Laboratory  
National Research Centre, Dokki, Cairo, Egypt

# THE SPECTRAL DISTRIBUTION OF SOLAR RADIATION AT THE EARTH'S SURFACE--ELEMENTS OF A MODEL

B. Leckner  
Solar Ener., v.20, no.2, 1978, p.143-150

A knowledge of the spectral distribution of solar radiation at the earth's surface is important for the development of many solar energy devices and for estimates of their performance. The physical mechanisms of atmospheric attenuation as well as the composition of the atmosphere are very complicated. A model is needed, which is suitable for a variety of technical applications. Such models have been proposed by Moon[1], Gates[2], and, using part of Gates' data Thekaekara[3]. The results are usually presented in the form of curves or tables of spectral distributions for a few cases. In order to make the information more generally applicable, the present work will deal with the input data and elements of calculation. By means of a computer, the conversion of input data into a spectral distribution is a very simple task. Furthermore, by such a presentation, modifications of the model may easily be introduced when desirable.

## A MODEL FOR THE CALCULATION OF SOLAR GLOBAL INSOLATION.

Douglas V. Hoyt  
Solar Energy, Vol. 21, No. 1, 1978, p. 27-35.

This paper describes the theoretical model for calculating true solar mean atmospheric transmission values that was used in the rehabilitation of the NWS insolation measurements. Transmission values are calculated for each of 26 NWS stations, for each day of a climatologically mean year, and may be used either as standard values to correct the measured values to or as a basis for such standard values. True solar noon insolation values, the clear day mean insolation values, and the radiation climatology at Boulder, Colorado, are calculated in addition to the true solar noon atmospheric transmission values, and these are compared to observations as a check on the validity of the model. The model values of insolation are always within 2.7 per cent of the measured values when they are on an absolute radiation scale and therefore within the  $\pm 5$  per cent accuracy[4] of the measurements. Model calculations are also compared to the theoretical model values given by Braslau and Dave[1].

## TOTAL SOLAR RADIATION IN MEXICO USING SUNSHINE HOURS AND METEOROLOGICAL DATA, by R. Almanza and S. Lopez.

Solar Energy, vol. 21, no. 5, 1978, p.441-448.

When compiling climatological maps of total radiation it is usual to employ the diffuse more direct measurements which are units of energy per unit time per unit area in a horizontal plane, by means of a pyranometer[1], even though other types of meteorological measurements of solar energy are available, as radiation data is the best source of information. However, in the absence of such measurements, it is feasible to use empirical relations to estimate global radiation from hours of insolation, percentage of possible insolation, or cloudiness. Alternatively, for a particular location the global radiation may be estimated using existing data for other location with similar latitude, topography and climate. When using insolation data and various methods to obtain empirically total radiation, the approximation is estimated to be within  $\pm 10$  per cent.

# CHARACTERISTICS OF CLEAR SKY NORMAL INCIDENCE SOLAR INSOLATION MEASURED WITH THE RG2 FILTER

G. W. Sadler

Solar Ener., v.20, no. 2, 1978, p.139-142

Clear sky normal incidence solar insolation received at the earth's surface occurs primarily within the wave length range of 0.3 to 3.0  $\mu\text{m}$ . The attenuation of the solar beam due to dry gas molecules, water vapor, dust and other aerosols is not uniform over the spectrum and the International Radiation Commission suggest that sharp cut-off filters be used to separate the spectrum into reasonably well defined bands. The wavelength ranges and the filter designations recommended are: 525-2800  $\mu\text{m}$  for filter OG1; 630-2800  $\mu\text{m}$  for filter RG2; and 710-2700  $\mu\text{m}$  for filter R3[1]. These three filters allow the energy distribution to be calculated for seven designated solar spectrum bands. Since no energy absorption by water vapor occurs below 630  $\mu\text{m}$ , the RG2 filter conveniently divides the solar spectrum into one region where the beam attenuation is not affected by water vapor and a second region where the attenuation is influenced by the level of precipitable water in the atmosphere. Also, the radiation intensity below 630  $\mu\text{m}$  (the UV and visible region) is sometimes used to estimate the turbidity coefficient,  $\beta$ , for the atmosphere.

## ON THE RELATION BETWEEN INSOLATION AND CLIMATOLOGICAL VARIABLES -- V. ESTIMATION OF AVAILABILITY OF SOLAR ENERGY.

C. Rapp and A.A.J. Hoffman.

Energy conversion, v.18, no.1, 1978, p.31-43.

**Abstract** A new procedure is developed for estimating availability of solar energy in localities where adequate data are not available. The hourly variations in solar intensity with day of the year during clear weather (essentially no clouds and unlimited visibility) are shown to follow regular repeatable patterns. These patterns have been determined for four south-western locations. From these data, it is possible to estimate the maximum possible available solar energy for perfectly clear weather. The effect of clouds and reduction in visibility is to reduce the solar intensity below the value appropriate to any hour of any day in clear weather. A study of the dependence of reduction in solar intensity on cloud cover and visibility is now being conducted for several southwestern locations. A model for the dependence of direct normal solar intensity on total insolation is also being developed.

# SOLAR INSOLATION MEASUREMENTS AT LAS VEGAS NEVADA

L.D. Spight

Solar Ener., v.20, no.2, 1978, p.197-203.

The successful, economic application of solar energy technology to heating and cooling at a particular location is dependent upon accurate information about the solar energy available and climatic conditions at that site. Such detailed information can be obtained only from direct measurements collected at the site in question. When such data are available, then some phenomenological modeling can be done, and the general and specific features of the model can be identified and separated by comparison with the models for other sites. Goldberg and Klein[1] (hereafter G & K) have initiated such modeling for three widely separated locations: Barrow, Alaska (71°N); Rockville, Maryland (39°N); and Balboa, Canal Zone in Panama (9°N). We have performed a similar analysis of the daily solar radiation at Las Vegas, Nevada (36°N), over the past few years. Comparison of these results with the work of G & K, particularly the comparison between Rockville and Las Vegas, serves to point out the large differences in the spectral distribution and availability of solar radiation due to local and regional climatic differences, even for sites with comparable latitudes. Somewhat similar analyses for San Diego, California (32.8°N) by Morgan and Craig[2] and for Singapore (1.3°N) by Tan and Goh[3] serve further to dramatize the overwhelming effect of local conditions on the availability of solar energy.

## California Solar Data Manual.

Lawrence Berkeley Lab. Mar 78, 6p

SAN-1846-T2 PC \$5.00/MF \$3.50

This solar data manual is aimed at the needs of designers, architects, engineers, homeowners, builders, and the growing number of ingenious and enthusiastic individuals through whose efforts the widespread use of the sun's energy will become a reality. Because it contains the most reliable solar data presently available in the State of California, this manual provides basic solar data needed to design residential or commercial heating systems, solar heating swimming pools, and solar air conditioning systems. Many other uses of the data are possible—for example, for agricultural applications. The data are provided in a variety of representations as an attempt to make the accessible and useful to the broadest possible audience.



**A SIMPLE PROCEDURE FOR ESTIMATING GLOBAL DAILY RADIATION ON ANY SURFACE.**

K.J.A. Revfeim.

J. Applied Meteorology, v.17, no.8, Aug.1978, p.1126-34.

Monthly means of measured daily radiation data from a defined horizontal site are used to estimate the prevailing atmospheric attenuation parameter. The estimation method uses the properties of the Fourier structure of attenuation, as a function of the hour angle, at that site, for a range of attenuation parameters. The Fourier structure of the parameter estimate is then used to calculate the global daily radiation of a 'nearby' site, of any orientation, by direct formula substitution.

**HOURLY VS DAILY METHOD OF COMPUTING INSOLATION ON INCLINED SURFACES,** by M. Iqbal.

Solar Energy, vol. 21, no. 6, 1978, p.485-489.

In this report, comparison has been carried out between the two methods of computation, daily vs hourly. To avoid difficulties associated with estimation of hourly or daily diffuse radiation on horizontal surfaces, actual longterm average data of three widely spread Canadian locations are employed (Table I).

In the next section, mathematical formulations of the two methods are presented.

**TECHNOLOGY AND MATERIALS FOR HARNESSING SOLAR POWER.**

D. F. Nuttall

Metals and Materials, April 1978, p. 46-47.

Solar heating panels, solar cells and thermoelectric generators are among the many devices helping harness the power of the sun. Consulting engineer Dr D. F. Nuttall outlines the requirements of practical solar-power converters, and the materials used in their construction.

**THE HARDWARE UNDER THE SUN.**

Environmental Science & Technology, v12, no.8, Aug.1978, p.879-881.

*A recent conference shed light on the latest efforts and trends in solar energy equipment and systems testing and standardization*

Public Utilities Fortnightly, v.102, no.7.

Sept.28, 1978

**ENERGY. (Special Issue).**

**Solar Energy — Will It Conserve Nonrenewable**

**Resources?.....Seymour Baron 31**

Analyses of the consumption of fossil and nuclear energy resources needed to produce and operate solar energy systems point up the need to develop less energy-intensive solar systems to make them competitive with existing energy alternatives.

**N79-27874/ Argonne National Lab., Ill. RELIABILITY AND MAINTAINABILITY EVALUATION OF FREEZING IN SOLAR SYSTEMS**

P. S. Chopra and R. M. Wolosewicz Sep. 1978 38 p refs (Contract W-31-109-eng-38)

(ANL/SDP/TM-78-3) Avail NTIS HC A03/MF A01

Based on a review of 47 operational solar demonstration sites, approximately 30% of these sites experienced freezing problems. Some of these problems were caused by inattention to engineering details. Other problems resulted from a lack of knowledge of the specific requirements of solar systems. The information reviewed on 47 of the operational solar demonstration sites indicated that water-glycol systems should provide more reliable freeze protection than water systems as long as an adequate glycol concentration is installed initially and then maintained. If glycol makeup is required, a manually operated pump is used. The water system freezing problems are due to several factors which are listed DOE

**WHAT'S GOING WRONG WITH THE SOLAR PROGRAMS?**

Pennie Waterman

Solar Heating and Cooling, Vol. 3, No. 4, August 1978, p. 22-26.

An interview with Walter Cosel, solar consultant for the Sheet Metal Workers International Assoc.

**ASSESSMENT OF ENERGY CONVERSION USING SOLAR ENERGY IN KANSAS.**

J.T. Pytlinski.

J. Energy, v.2, no.4, July-Aug.1978, p.250-53.

**ON THE RELATION BETWEEN GLOBAL INSOLATION ON  
HORIZONTAL AND TILTED SURFACES**, by Donald Rapp and  
David Oxley  
Energy Conversion, vol. 18, no. 1, 1978, p. 39-43

**Abstract:** Global insolation has been measured at many sites on a horizontal surface, but is needed on a tilted surface. A study has been made of patterns of global insolation for 12 months at Fort Hood, Texas, where measurements are made on both horizontal and tilted surfaces. The results indicate that, during clear weather, use of a geometrical formula for converting horizontal to tilted insolation for direct rays result in values 3.3% high. For the twelve month period March, 1976 February, 1977, including all weather, but only hours where the insolation on the tilted surface is greater than 22 Langley/hr, the geometrical formula is 4.6% high. It is concluded that the geometrical formula can be used with small corrections.

**N79-28791/** Public Service Co. of New Mexico, Albuquerque.  
**TECHNICAL AND ECONOMIC ASSESSMENT OF SOLAR  
HYBRID REPOWERING Final Report**  
Sep 1978 572 p refs  
(Contract EG-77-C-03-1608)  
(SAN-1608-4-1) Avail. NTIS HC A24/MF A01

The study presented was divided into the six primary tasks to allow a systematic investigation of the concept: (1) market survey and cost/benefit analysis, (2) study unit selection, (3) cost estimates; (4) unit economic analysis, (5) program planning, future phases, and (6) program management. Reeves Station No. 2 at Albuquerque, New Mexico, was selected for repowering with a design goal of 50 percent (25 MWe). The solar system design is based on the 10 MW solar central receiver pilot plant preliminary design for Barstow, California. DOE

**A78-19838** Transmission of sunlight through a uniform water-drop atmosphere. D. C. de Packh (Entropy Research, Hollywood, Md.). *Solar Energy*, vol. 20, no. 1, 1978, p. 93-95.

A computer calculation is derived for the transmission of normal-incidence parallel radiation through a uniform water-drop atmosphere. The calculation employs a Chandrasekhar transport equation which is in effect the time-dependent Boltzmann equation. Although the analysis assumes that the collector is directed at the sun, which is at the zenith, it is also applicable to other cases. S.C.S.

**SOLAR FRAUD, ROUND 2**, by Carlo La Porta.  
*Solar Heating & Cooling*, vol. 3, no. 5, October 1978, p. 34-36.

It is not unreasonable to expect solar manufacturers to offer warranties to cover their products, but it is unreasonable to require them to go so much further than is commonly required of other industries.

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**A78-34933** Sunstations. E. Berman (Boston University, Boston, Mass.), A. Braunstein (Tel Aviv University, Tel Aviv, Israel), and D. Biran. *Solar Energy*, vol. 20, no. 6, 1978, p. 465-467.

A method of obtaining insolation data is described which provides information directly usable in the sizing of solar equipment. The method is particularly valuable for the collection of data at a large number of sites where equipment cost and availability of technically trained personnel are critical. The device consists of a calibrated solar cell, and electrochemical accumulator and associated electronic equipment having the following characteristics: capacity 3600 kWh/sq m; temperature range -55 to +71 C; low cost; no field maintenance; reproducibility + or - 5%. (Author)

ON-142,795 1977  
ESTIMATING SOLAR ENERGY AVAILABLE FOR COLLECTION.  
18p. 1977.

**Horizon Industries,** A compact guide that tells how to calculate the amount  
**North Hollywood,** of solar energy that will strike almost any collector in  
**CA.** the United States. It is built around a set of computer  
**Insolation** generated tables that give insolation for flat and inclin-  
**Solar collectors** ed collectors, at each hour of the day, for each month  
of the year. The six tables in the set cover latitudes  
from 24 to 64 degrees north. Detailed instructions are  
given for using the tables and for finding insolation at  
latitudes and inclinations not listed in them. An original  
method for dealing with collectors that face other than  
due south is described. Instructions and data are includ-  
ed for predicting the effect of cloudiness. Recommen-  
dations are made for selecting the optimum collector  
orientation. Completely illustrated, with worked-out  
examples for every calculation. 20 Pages

**ON THE RELATION BETWEEN INSOLATION AND CLIMATOLOGICAL  
VARIABLES --IV. CONSTRUCTION OF A MODEL YEAR OF  
SOLAR INTENSITY AND CLIMATE.**

**Donald Rapp and A.A.J. Hoffman**

**Energy Conversion, vol. 17, no. 4, 1977, p. 173-181**

**Abstract**—Proper design and sizing of a solar energy heating and/or cooling system involves an assess-  
ment of the local availability of solar energy and its relationship to local climate.

A study is made of availability of solar energy at Fort Hood, Texas for the period 1961-1969. Hourly values of climatological variables were obtained from the National Climatic Center. These are combined with correlations of solar intensity with cloud cover and visibility to obtain hourly estimates of total insolation and normal incidence solar intensity. Monthly totals are calculated for each of the 108 months in 1961-1969, and average monthly solar intensities are obtained. For each month of the year, the month in the 1961-1969 period that most closely approximated the average solar intensities, as well as the average heating and cooling degree-days, is chosen to prepare an average model year. This average has hourly values of solar intensities as well as climatological variables. Hourly models are also prepared for the worst winter and summer months in the period. Finally, a study is made of correlations of solar availability with degree-days. It is found that there is very little correlation in winter, but in summer sunny days are highly correlated with hot days.

**ESTIMATION OF THE TOTAL SOLAR RADIATION FROM  
METEOROLOGICAL DATA.**

**J.A. Sabbagh, et al.**

**Solar Energy, v.19, 1977, p.307-11.**

The estimation of the performance of any solar energy utilizing equipment necessitates the knowledge of the solar radiation data which have been gained over a long period of time. Investigators have developed many empirical formulas to estimate the solar radiation using various parameters[1-4]. These parameters are, the climatological data which has been measured for prolonged time in various locations including sunshine hours; relative humidity; maximum and minimum temperatures; cloud cover and geographical location. Angstrom[5,6], Black[7], Glover and McCulloch[8] and Sabbagh-Sayigh and El-Salam[9] used the sunshine hours to estimate the mean solar radiation. Lui and Jordan[10], Kreith[11] Sharma and Pal[12] and Whillier[13,14] used the declination angle and the latitude in their formulas. Bennett[15] and Mateer[16] combined the sunshine duration, the declination angle and the latitude to develop their formula. Swartman and Ogunlade[17] used the relative humidity in addition to the sunshine duration in establishing their formula. Reddy *et al.*[18,19] obtained their formula by using sunshine duration, the relative humidity and mean temperature, while in another formula Reddy[19] suggested the use of the number of rainy days, sunshine duration and a factor which depends on the latitude and the location of the place relative to the sea, in computing the daily total shortwave solar radiation.

**Kondrat'ev, Kirill (Akovlevich).**

**Radiation regime of inclined surfaces /by K. Ya. Kondratyev, with the assistance of M. P. Fedorova. — Geneva : Secretariat of the World Meteorological Organization, 1977.**

xiv, 82 p. : ill. ; 28 cm. -- (WMO ; no. 467) (Technical note - World Meteorological Organization ; no. 152) Sw\*\*\*

Summary in English, French, Russian and Spanish.

Bibliography: p. 62-63.

ISBN 9263104670

I. Solar radiation. 2. Atmospheric radiation. I. Fedorova, M. P., joint author. II. Title. III. Title: Inclined surfaces. IV. Series: World Meteorological Organization. WMO publications ; no. 467. V. Series: World Meteorological Organization. Technical note ; no. 152.

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**ON THE RELATION BETWEEN INSOLATION AND CLIMATOLOGICAL VARIABLES -- III. THE RELATION BETWEEN NORMAL INCIDENCE SOLAR INTENSITY, TOTLA INSOLATION, AND WEATHER AT FORT HOOD, TEXAS**

Donald Rapp and A. A. J. Hoffman

Energy Conversion, vol. 17, no. 4, 1977, p. 163-172

**Abstract**—An examination of normal incidence solar intensity (NISI) data taken at Fort Hood, Texas, from September 1974 through November 1975 has shown repetitive patterns for intensities in clear weather. A correlation is developed which predicts the NISI at any hour of any day of the year in clear weather with a high degree of accuracy. A study of NISI during cloudy weather has yielded a correlation for  $f_N$ , the fraction of clear day NISI, as a function of cloud cover and visibility. The result is a semi-empirical model which provides a unique prediction of the NISI at all times for all weather conditions. Using this model, it should be possible to convert long-term data on cloud cover and visibility to long-term NISI patterns.

**CALCULATION OF MONTHLY AVERAGE INSOLATION ON TILTED SURFACES.**

S. A. Klein

Solar Energy, vol. 19, no. 4, 1977, p. 325 - 329

**Abstract**—Several simplified design procedures for solar energy systems require monthly average meteorological data. Monthly average daily totals of the solar radiation incident on a horizontal surface are available. However, radiation data on tilted surfaces, required by the design procedures, are generally not available. A simple method of estimating the average daily radiation for each calendar month on surfaces facing directly towards the equator has been presented by Liu and Jordan[1]. This method is verified with experimental measurements and extended to allow calculation of monthly average radiation on surfaces of a wide range of orientations.

**THE DETERMINATION OF HOURLY INSOLATION ON AN INCLINED PLANE USING A DIFFUSE IRRADIANCE MODEL BASED ON HOURLY MEASURED GLOBAL HORIZONTAL INSOLATION**

J. W. Bugler

Vol. 19, no. 5, 1977, p. 477-491.

**Abstract**—Using only measured hourly values of global insolation on a horizontal surface, a method has been developed for computing the corresponding hourly values of insolation on a surface inclined at any angle and oriented in any direction. The method uses a solar radiation model in which the diffuse component is calculated from global horizontal radiation using three different relationships; the appropriate equation is selected according to the value of the ratio of measured hourly global insolation to hourly global insolation computed for clear sky conditions. The method has been checked using measured hourly values in Melbourne over a 5-yr period of insolation on both a

**STOCHASTIC MODELING AND FORECASTING OF SOLAR RADIATION DATA**

T. N. Goh and K. J. Tan

Solar Energy

Vol. 19 no. 6

p. 755-757

1977

Modeling of solar radiation data is an essential step in the design and performance prediction of solar energy conversion systems. This paper considers the requirements for solar radiation models from a forecast information user's point of view, and proposes a new modeling approach in which stochastic time series modeling methodology is used to fully extract the statistical properties of solar radiation data and present them in a form suitable for forecasting. This is followed by an illustrative example and a discussion on the potential application of the methodology in solar energy research.

**DAILY AND YEARLY TIME VARIATION OF SOLAR AND TERRESTRIAL RADIATION FLUXES AD DEDUCED FROM MANY YEARS RECORDS AT HAMBURG**

Fritz Kasten

Solar Energy

Vol. 19, no. 5, 1977

p. 589-593

Whereas long-time measuring series of solar radiation are available from many stations of the world, continuous records of terrestrial radiation fluxes were not possible before Schulze[1] had introduced a weather-proof pyrrometer with an IR-transparent polyethylene dome in 1953. Up to now, more than 20 yr records of all shortwave and longwave radiation fluxes have been obtained at the Meteorological Observatory Hamburg of the German Weather Service. In the early years of recording, daily sums were obtained by planimetry of the recorded curves. From 1964 on, automatic integrators were used to generate hourly sums of all measured radiation fluxes on a routine basis.

**SOLAR AND DIFFUSE RADIATION AT BARCELONA**

J. I. Jimenez, J. E. Llebot and J.

Casas-Vazquez.

Solar Energy

Vol. 19 no. 6

p. 775-776

1977,

To measure short wave radiation, we used two Moll-Gorczynski solarimeters mounted on a platform over the roof of one of the University's buildings. The platform was about 2 m high and no appreciable obstacles were in the neighborhood of the solarimeters.

As the surface is not variable with the season (not vegetable), the surface's albedo was not measured continuously. However, the surface's albedo was periodically measured with a Kipp-Zonen albedometer with different soil conditions (wet and dry) and with different solar heights.

**VALIDITY OF THE ISOTROPIC-DISTRIBUTION APPROXIMATION IN SOLAR ENERGY ESTIMATIONS**

J. V. Dave

Solar Energy, vol. 19, no. 4, 1977, p. 331 - 333

**Abstract**—Results of numerical simulation are presented for the diffuse and direct energy passing through a Sun-facing flat surface located at the bottom of plane-parallel models of non-absorbing, homogeneous atmospheres. Computations of the diffuse component were carried out with a high degree of accuracy, and also were carried out using the well-known, isotropic-distribution approximation for the sky energy. It is shown that the results obtained with the isotropic-distribution approximation are consistently smaller than those obtained with the exact procedure. These two sets of results can differ by a factor 1-6 depending upon the optical characteristics of the model and the position of the Sun.

**THE BIG PUSH FOR SOLAR MEASUREMENT**

George L. Kirk and Walter J. Scholes

Optical Spectra, June 1977, vol. 11, issue 6,  
p. 38-39

A national solar energy pledge has implanted the urgency of precise solar radiation measurement and the instrumentation to go with it.

**METHOD FOR EVALUATING THE SOLAR ENERGY PROVIDED BY A FLAT INSOLATOR**

R. Gicquel

International Chemical Engineering

Vol. 17 no. 4 October 1977

p. 575-582

*A method is proposed for evaluating the solar energy provided by a flat insulator at any inclination and orientation on the basis of available meteorological data. The optimum inclination is shown to depend on the use to which the heat is to be put, and the overall efficiency of the collector is found to be strongly dependent on the temperature level at which the heat is to be delivered.*

**A NUMERICAL SOLAR RADIATION MODEL BASED ON STANDARD METEOROLOGICAL OBSERVATIONS,** by M. A. Atwater and

J. T. Ball

Solar Energy, vol. 21, no. 3, 1978, p. 163-170

**Catalog of Solar Radiation Measuring Equipment.**

E. A. Carter, W. G. Breithaupt, C. S. Dahagam, and A. M. Patel.

Alabama Univ., Huntsville. Kenneth E. Johnson

Environmental and Energy Center. Apr 77. 164p

ORO/5362-1 Price code: PC A08/MF A01

A listing of national and international manufacturers of solar radiation measuring equipment is presented. Product performance, applications, and economic data for each instrument are included. The different instruments included are pyrheliometers, pyrgometers, pyranometers and net pyrradiometers.

**THE SOLAR SPECTRUM AT TYPICAL CLEAR WEATHER DAYS**

K. W. Boer

Solar Energy

Vol. 19, no. 5, 1977

p. 525-538

**Abstract**—The solar spectrum in the range of 300 <  $\lambda$  < 1500 nm is given for 5 typical clear weather days. These days are selected to represent typical seasonal conditions in respect to air mass, water vapor, ozone and turbidity. Present data are reviewed and specific conditions are selected. The spectral distribution of the irradiance is given for the direct component, the scattered skylight, the total flux on a horizontal surface and the flux on an inclined surface normal to the direct beam.

**CORRELATION EQUATION FOR HOURLY DIFFUSE RADIATION ON A HORIZONTAL SURFACE**

J. F. Orgill and K. G. T. Hollands

Solar Energy, vol. 19, no. 4, 1977, p. 357 - 359

**Abstract**—This paper presents an analysis of hourly diffuse radiation on a horizontal surface and recommends an equation to determine the hourly ratio of diffuse-to-total radiation received in a horizontal surface. The results of the new correlation equation are compared with earlier equations with recommendations made as to its use with solar energy computer simulation programs.

**ON THE RELATION BETWEEN INSOLATION AND CLIMATOLOGICAL VARIABLES--II. PREDICTION OF INSOLATION AT FORT HOOD, TEXAS**

Donald Rapp and A. A. J. Hoffman

Energy Conversion

Vol. 17 no. 1

1977

p. 31-35

TJ  
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International Solar Energy Society, UK Section,  
Economic & commercial assessment of  
solar energy conversion : conference (C12)  
at the Royal Institution July 1977. —  
London : UK - ISES, c1977.  
98 p. : ill. ; 30 cm.  
Includes bibliographical references.

The nine papers discuss important current issues dealing with the economics of solar heating, commercial aspects of solar water heating, heating pumps, solar cells, returns from investment and projected markets. Charts, tables, equations and references complement the text. A sample of the contents: Cost factors in photovoltaic energy conversion with solar concentration by J. E. Parrott; and Projected market penetration of solar heating and cooling in the USA. by P.C. Spewak.

## TECHNICAL AND SOCIO-ECONOMIC ASPECTS OF SOLAR ENERGY AND RURAL DEVELOPMENT IN DEVELOPING COUNTRIES.

R. Ramakumar.  
Solar Energy.  
Vol. 19 no. 6 1977  
p.643-649.

Abstract—In developing countries, the losing race between demography and development is resulting in the emergence of the dual economy. Unless checked, this will lead to social and political tensions with global consequences. A healthy and dynamic rural growth is necessary to correct this situation. Energy can play a vital role in this process. A step-by-step approach is presented for the adoption of technologies designed to exploit renewable (solar) energy sources at the rural level. It is centered around the establishment of rural energy centers to improve the basic living environment. In due course, the role of these centers is to be expanded to encompass agricultural and small-scale industrial activities. The technical and socio economic aspects of the step-by-step introduction of solar energy systems in rural areas in developing countries are discussed.

TJ  
810  
.S623  
Solar energy engineering / edited by A.  
A. M. Sayigh. New York : Academic  
Press, 1977.  
xx, 506 p. : ill. ; 24 cm. (Energy  
series)

The total and spectral solar irradiance is considered along with a solar energy availability prediction from climatological data, heat transfer for solar energy utilization, liquid flat plate collectors, convective heat transfer effects within Honeycomb structures for flat plate solar collectors, solar air heaters and their applications, concentrating collectors, a solar pond, and solar furnaces. Attention is also given to photovoltaic conversion, an application of solar energy in space, the conversion of solar energy into electricity, the storage of solar energy, refrigeration and air conditioning, solar heating and cooling of homes, the solar production of hydrogen, solar energy measuring equipment, the fundamentals of water desalination, and questions regarding the economics of solar energy.

, A. A.  
nt

## SOLAR ENERGY RESEARCH: MAKING SOLAR AFTER THE NUCLEAR MODEL?

Gina Bari Kolata

Science, vol. 197, no. 4300, July 15, 1977,  
p. 241-245, 294

The first in a series of Research News articles examining recent developments in solar energy research.

## AUTOCORRELATION AND STOCHASTIC MODELLING OF INSOLATION SEQUENCES.

B. J. Brinkworth

Solar Energy, vol. 19, no. 4, 1977, p. 343 - 347

Abstract—The output of solar thermal systems is sensitive to variations in the solar energy input. Among the important features of these variations is their sequential character, which has not hitherto been taken into account. It is shown that the sequential characteristics of the daily insolation can be represented in simple numerical terms, derived from the autocorrelation functions of a straightforward stochastic model. Synthetic sequences can then be generated, which match the long-term characteristics of the insolation with respect to its sequential properties, as well as to the seasonal trend and the variance of the fluctuations.

Applied Solar Energy (Gellotekhnika)  
v.13, no.5, p.1-5

1977

## ADVANCES IN AND PROSPECTS FOR THE DEVELOPMENT OF SOLAR POWER GENERATION IN THE USSR. S. A. Azimov.

THE DEVELOPMENT OF SOLAR EQUIPMENT STANDARDS.  
C.A. Beach.  
Solar Heating & Cooling, Oct.1977, p.18-21.

Florida is leading the other states, and the federal government.

TJ	Energy development II ... c1976. (Card 2)	
153	covering papers presented at the National	
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Solar Radiation and Energy Measurements, by D. Biran and A. Braunstein.....		
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810	joint conference, American Section, Inter-	
.S48	national Solar Energy Society and Solar En-	
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SOLAR RADIATION UNDER A LAYER OF SCATTERED CLOUDS	
Marvin L. Wesly and Robert C. Lipschutz	
Solar Energy, v.18, no.5, 1976, p.467-473	
The purpose of this paper is to provide a simple procedure for	
estimating values of $D$ and $I$ that can be used in comparisons of	
the theoretical performances of solar collectors of different	
designs. The amount of solar energy collected at the focal point of	
a Sun-tracking parabolic reflector is, of course, extremely	
sensitive to the direct-beam attenuation caused by clouds. On the	
other hand, the collection by flat-plate receptors is less sensitive to	
such shading because the decrease of the direct component is	
typically accompanied by increased diffuse radiation. The	
characteristics of devices such as the compound parabolic	
concentrator (1) lie in between. These collectors view a fairly large	
portion of the sky (obviating the need for continuous Sun tracking)	
so that both the direct and some portion of the diffuse radiation is	
gathered.	
A POSSIBLE "AVERAGE" WEATHER YEAR ON ISRAEL'S	
COASTAL PLAIN FOR SOLAR SYSTEM SIMULATIONS, by	
S. Schweitzer.	
Solar Energy, vol. 21, no. 6, 1978, p.511-515.	

**LAW AND SOLAR ENERGY SYSTEMS: LEGAL IMPEDIMENTS AND IN-  
DUCEMENTS TO SOLAR ENERGY SYSTEMS**

Richard L. Robbins

Solar Energy, vol.18, p371-379, no.5, 1976

Innovations in building design and construction and in the use of new heating and cooling methods have been slow to be applied in the United States. Much of this is due to the fragmented and conservative structure of the construction industry. But local and state laws, as well as institutional constraints, have also severely limited change.

TJ  
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**Solar Energy Seminar, University of  
Regina and University of Saskatchewan,  
1976.**

Applications of solar energy :  
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Regina, Sask. : University of Regina,  
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165 p. : ill. ; 23 cm. (Canadian  
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Aspects of the Radiation Climatology of Southern  
Saskatchewan of Relevance to Solar Energy Engineers,  
John E. Hay, Department of Geography, University of  
British Columbia, Vancouver, B.C. . . . . 4

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THE SEASONAL DISTRIBUTION OF THE IN-  
COMING SOLAR RADIATION IN MEXICO

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**Rankins, William H.**

The solar energy notebook / written by  
William H. Rankins III and David A. Wilson;  
photography by Faris A. Ashkar. — Black  
Mountain, N. C. : Lorien House, cl976.  
56 p.

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35		Design Outside Temperature
37	Chapter 8	Mean Daily Solar Radiation
44		Sunshine Percentage of The Horizontal Valu
47	Chapter 9	Mean Total Hours Sunshine
53	Chapter 10	Local Climatological Data

**Environmental Action Reprint Series**

**SOLAR GUIDE AND CALCULATOR**, by Edward  
Mazria and David Winiatzky

This is a simplified method of calculating the sun  
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or horizontal surface from latitudes 28° to 48° in  
4° increments. Provides a basic understanding of  
where and how the sun works in relation to a build-  
ing and site. Acetate overlays simplify the proce-  
dure to a graphic method.  
20 pages, pamphlet (c 1976) . . . . . \$4.25

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- 3.2 Effect of Atmospheric Constituents on Solar Energy. . .
- 3.3 Insolation Values at the Surface of the Earth . . .
- 3.3.1 Calculation of Insolation Values and Spectra from First Pr
- 3.3.2 Available Measurements and Correlations of Terrestrial Insi
- 3.3.3 Adaptation of Insolation Results to Flat Plate Calculation
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## SOLAR - COLLECTORS, CONCENTRATORS, AND SELECTIVE OPTICAL FILMS

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2896	Conference, 14th, Boston, 1979.	
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HEAT LOSS CHARACTERISTICS OF AN EVACUATED PLATE-IN-TUBE COLLECTOR, by G.T. Roberts, Solar Energy, vol. 22, no. 2, 1979, p.137-141.

**Abstract**—An experimental and theoretical investigation is described into the heat loss from a flat plate placed inside a partially evacuated glass tube. The conditions required to prevent convection losses are discussed and the effect of introducing a low thermal conductivity gas evaluated.

**NSO-18586/** National Technical Information Service, Springfield, Va.

**FLAT PLATE SOLAR COLLECTOR DESIGN AND PERFORMANCE. CITATIONS FROM THE NTIS DATA BASE Progress Report, 1976 - Jul. 1979**

Audrey S. Hundemann Sep 1979 168 p Supersedes NTIS/PS-78/0840  
(NTIS/PS-79/0928/6, NTIS/PS-78/0840) Avail NTIS HC \$28.00/MF \$28.00 CSCL 10A

Federally-funded research on the design and thermal efficiency of air- and liquid-type flat plate collectors is discussed. Topic areas cover convection characteristics, methods to reduce heat loss, optical coatings, and corrosion control. Emphasis of the bibliography is on basic research studies. [This updated bibliography contains 160 abstracts, 63 of which are new entries to the previous edition.] GRA

**NSO-18687/** National Technical Information Service, Springfield, Va.

**FLAT PLATE SOLAR COLLECTOR DESIGN AND PERFORMANCE. CITATIONS FROM THE ENGINEERING INDEX DATA BASE Progress Report, 1970 - Jul. 1979**

Audrey S. Hundemann Sep 1979 180 p Supersedes NTIS/PS-78/0841  
(NTIS/PS-79/0929/4, NTIS/PS-78/0841) Avail NTIS HC \$28.00/MF \$28.00 CSCL 10A

Citations from worldwide literature on the design, thermal performance, and optimization of air- and liquid-type flat plate collectors are covered. Topic areas include heat loss and heat transfer, effect of orientation, corrosion protection, optical coatings, enhancement of performance through the use of planar reflectors, and the effect of honeycomb layers on collector performance. A few studies pertain to grooved, corrugated, or V-trough collectors. Abstracts dealing with methods of measuring the performance of flat plate collectors and computer optimization studies are included. This bibliography contains 174 abstracts, 30 of which are new entries to the previous edition. GRA

SOLAR COLLECTOR PAINTS-HOW DO THEY COMPARE?  
Popular Science, vol 214, no 5, May 1979, p. 134.

A general design method for closed-loop solar energy systems. S.A. Klein, W.A. Beckman.

Solar Energy. v. 22, no. 3, 1979, p. 269-282.

**Abstract**—A general design method is presented for closed loop energy systems consisting of solar collectors, sensible energy storage and a closed-loop flow circuit in which thermal energy is supplied (through heat exchange) to a load above a specified minimum temperature. It is assumed that the energy supplied to the load is used at a constant thermal efficiency. Computer simulations were used to estimate the long-term thermal performance of these systems, and correlations between the system performance and the system design parameters, such as the collector characteristics, load size, climatic data, and the minimum useful temperature, are presented.

**Parabolic Concentrating Collector: A Tutorial.**

Jet Propulsion Lab., 15 Feb 79, 48p

DOE/JPL-1060-12 PC \$6.00/MF \$3.50

A tutorial overview of point-focusing parabolic collectors is presented. Optical and thermal characteristics of such collectors are discussed. Data representing typical achievable collector efficiencies are presented and the importance of balancing collector cost with concentrator quality is argued through the development of a figure of merit for the collector. The impact of receiver temperature on performance is assessed and the general observation made that temperatures much in excess of 1500 to 2000 exp 0 F can actually result in decreased performance. Various types of two-axis tracking collectors are described, including the standard parabolic deep dish, Cassegrainian and Fresnel, as well as two forms of fixed mirrors with articulating receivers. The present DOE program to develop these devices is briefly discussed, as are present and project costs for these collectors. Pricing information is presented for the only known commercial design available on the open market.

A79-47797

An evacuated glass tube solar collector and its application to a solar cooling, heating and hot water supply system for the hospital in Kinki University. K. Hinotani, K. Kanatani, and M. Osumi (Sanyo Electric Co., Ltd., Hirakata, Osaka, Japan). *Solar Energy*, vol. 22, no. 6, 1979, p. 535-545. 5 refs.

EFFECT OF COVER MATERIAL AND PLASTIC HONEYCOMB ON COLLECTOR PERFORMANCE, by R. K. Wedel, R.E. Dammann, and S.A. Greenberg.

Journal of Energy, vol. 3, no. 1, Jan./Feb. 1979, p. 62-64.

**D**EPENDING upon their end use, solar collectors utilize either one or two covers. In general, swimming pool collectors for midsummer application need no cover; however, collectors used to extend the swim season have one cover of glass or plastic, as do collectors used for space heating and hot water heating in mild climates. For heating in cold climates, hot water heating, and for air-conditioning applications, collectors are used that have either a selective black absorber with one or two covers or a flat black absorber with two covers. The cover materials used are either glass or plastic. For high-temperature collectors, glass covers are preferred because they are opaque in the longer wavelength (infrared) region and improve the efficiency by reducing radiation of energy to the sky. The plastics, on the other hand, are cheaper and lighter and, therefore, offer an attractive alternative when their optical properties are similar or better than those of glass.

**Performance Evaluation of Solar Films and Screens.**

John-Manville Sales Corp., Apr 79, 71p

AD-A070 039/3WE PC \$5.25/MF \$3.00

The use of solar films and screens to reduce energy usage is surveyed by means of Market and Literature Surveys that provide basic information on the availability, manufacture, function, cost, and solar optical properties of solar films and screens. A simplified method of determining potential energy savings is given in a step by step format that includes consideration of solar heat gain, heat loss, and daylighting aspects of the application of solar films and screens. This simplified hand calculation procedure should provide an interim means of providing the energy saving information required by the Energy Conservation Investment Program. More sophisticated methods of calculation are under development by the Lawrence Berkeley Laboratory under a contract with the Department of Energy. This computer model technique combined with empirical data should be available by mid to end of year 1979.

**EFFICIENT FRESNEL LENS FOR SOLAR CONCENTRATION**, by E.M. Kritchman, A.A. Friesem and G. Yekutieli, *Solar Energy*, vol. 22, no. 2, 1979, p.119-125.

**Abstract**—The development effort in optical components for optimally concentrating solar energy has thus far emphasized reflecting elements, such as cylindrical and compound parabolic mirrors. In this paper we consider transmission elements, particularly a new design for an efficient linear Fresnel lens capable of high concentration for a given acceptance angle. The predicted performance of the lens is comparable to that of the "ideal" reflector, while providing greater reliability at a lower cost.

**Characterization of Crushed Glass as a Transpired Air Heating Solar Collector Material.**  
Los Alamos Scientific Lab., 1979. 6 p  
LA-UR-79-1336 PC \$5.00/MF \$3.50

The use of crushed glass matrices as the heat-absorbing media in air heating solar collectors is investigated. An experimental program was undertaken to characterize the most likely candidate glass types and sizes by measuring pressure drops, optical extinction coefficients, and volumetric heat transfer coefficients. Bed efficiencies were also measured and found to be similar to those expected for screen matrices unless critical amounts of clear glass were used as a top layer, which results in lower efficiency.

**A NEW APPROACH TO LOW COST LARGE AREA SELECTIVE SURFACES FOR PHOTOTHERMAL CONVERSION.** B. K. Gupta, F. K. Tiwari, O. P. Agnihotri.

*Energy Research*, vol 3, no 4, October-December 1979, p. 371-377.

In the present study, selective black paint coatings have been prepared by coating reflective metal particles with a layer of selective black material. The coated particles were mixed in a binder and applied easily as a thin layer onto aluminium or galvanized iron (G.I.) sheet. Three selective black materials, namely  $\text{CuO}$ ,  $\text{CoO}$  and  $\text{Fe}_3\text{O}_4 + \text{CuO}$  have been deposited on zinc metal powder. The solar absorptance of the coatings is  $>0.95$  and the emissivity is  $\approx 0.4$ . The thickness of the coatings was about 20 to 30  $\mu\text{m}$ . The emissivity decreases as the thickness increases, while the solar absorptivity does not change appreciably. The improvement in the collector efficiency, which is the ratio of the temperature increase above the temperature of the standard panel to the temperature increase of the standard panel along the ambient temperature, is estimated to be around 11 per cent. The process is potentially a low cost one for large scale application in solar photothermal conversion.

**N80 17563#** Sandia Labs., Albuquerque, N. Mex.  
**SUNTECH SOLAR LINEAR ARRAY THERMAL SYSTEM (SLATS) TEST RESULTS** Summary Report  
H. J. Gerwin Aug 1979 58 p refs  
(Contract EY 76 C 04 0789)  
(SAND 79 0658) Avail NTIS HC A04/MF A01

A fixed receiver, movable reflector solar collector system was tested. The collector included 260 sq m of reflector area. Thermal energy was transferred from the linear receiver to a heat exchanger by water and from the heat exchanger to the thermal storage tanks by Therminol 66. The collector system start-up and operation over a period of 16 months is described. Several data tables and many graphical displays show the performance characteristics under various operating parameters. DOE

**FLAT-PLATE SOLAR COLLECTOR MATERIALS.** M. L. Day and D. S. Remer.

*Sampe Quarterly*, vol 11, no 1, November 1979, p. 28-37.

The desirability of specific materials and designs for conventional flat plate solar collector components is considered. Then a methodology for choosing the most economic component is presented, consisting of a computer simulation and a rate of return analysis. The effect of rising conventional fuel costs is examined. Examples of using the methodology are given, based on Southern California climatic and user demand conditions. Selective absorber plate coatings and film inner glazing are shown to be economic, yielding a rate of return of 23% and 29%, respectively.

**A79-50542** Static concentrators for two-sided photovoltaic solar cells. J. Sanjurjo and G. Sala (Madrid, Universidad Politécnica, Madrid, Spain). *Solar Energy*, vol. 23, no. 1, 1979, p. 53-60. 5 refs.

The use of cylindrical mirrors to concentrate radiant energy onto a two-sided photovoltaic absorber has been studied. Both theoretical and experimental results for the illumination intensity at the exit aperture were obtained for such a concentrator. A mathematical approach was devised to obtain the theoretical intensity distribution. Experimental intensity distribution was measured for a set of different mirrors. The mirrors all had the same profile but were made of different materials and had different reflecting surfaces. The main conclusion was that the intensity distribution at the exit aperture is very inhomogeneous. The concentration was very low (less than 3) for a certain zone of the absorber, regardless of the light rays incidence angle. Another important conclusion was the effect of truncating the mirror, which was found to be a reduction in the average number of reflections of the incident light. Finally, an arrangement, different from the theoretical one, is presented for the placement of the absorber in the concentrator. (Author)

# HIGH TEMPERATURE SOLAR COLLECTOR WITH OPTIMAL CONCENTRATION: NON-FOCUSING FRESNEL LENS WITH SECONDARY CONCENTRATORS

M. Collares-Pereira

Solar Energy, vol. 23, no. 5, 1979, pp. 409-420.

**Abstract**—A non-evacuated collector consisting of a linear Fresnel lens and a second stage concentrator of the CPC type is described and tested in detail. Use of a Fresnel lens accomplishes two different objectives simultaneously; it allows for the design of a nearly ideal light collector (of the CPC type) of high concentration and height-to-aperture ratio close to 1 and plays the role of a cover, making the collector less sensitive to the environment than one with exposed reflector surface. The geometric concentration is 15.36 and the acceptance half angle is 3°. The optical efficiency measured with an Active Cavity Radiometer (ACR) is 65.6 per cent and the efficiency at  $\Delta T/I$  of 0.235 is 48 per cent ( $\Delta T = T_{\text{av fluid}} - T_{\text{amb}} = 200^\circ\text{C}$ ,  $I_{\text{ACR}} = 850 \text{ W/m}^2$ ). Heat loss measurements for double glazed configurations are reported and the resulting efficiency at  $\Delta T/I$  of 0.3 is predicted to be 48 per cent. These numbers are expected to be raised by 3 percentage points for a next generation of lenses. The collector is mounted with its tracking axis oriented NS since EW tracking axis orientation is impractical for a linear Fresnel lens, but its wide acceptance angle permits tracking by a simple clock mechanism at constant speed. Two different strategies are considered (i) polar mount, (ii) two adjustments of the tracking axis a year (summer and winter); the predicted yearly performance is calculated for four locations and four working fluid temperatures.

The projected cost is estimated to be \$70.00/m<sup>2</sup> (1976 dollars), possible because the construction of the collector lends itself to the use of inexpensive materials such as plastic and glass.

**N80-10593** Drexel Univ., Philadelphia, Pa.  
**OPTIMAL CONTROL OF DISTRIBUTED PARAMETER SYSTEMS FOR SOLAR THERMAL APPLICATIONS**  
Ph.D. Thesis

Abraham Orbach 1979 252 p  
Avail. Univ. Microfilms Order No. 7923085

The necessary conditions for optimality, which generate a set of equations whose solution yields the optimal control, were derived. It was shown that if the system and the performance index were bilinear and if the control vector was constrained, the optimal solution yielded a bang-bang policy for which the switching functions were obtained. These results were applied to the optimal control of the solar collector loop systems where the objective was to control the fluid velocity so as to maximize the net energy collected. A sensitivity study of a nonlinear first order in time and space system is presented. Three types of distributed parameter models, which represent the dynamics of the flat plate solar collector were derived. Dissert. Abstr.

**SYNTHETIC-RUBBER EXTRUSIONS FORM LOW COST ROLL-ON SOLAR COLLECTOR.** V. Elaine Smay.

Popular Science, vol 214, no 6, June 1979, p. 120-125.

You assemble it on site: Just unroll the mats, connect the tubes, and glue to your roof.

**NASA CR-3111** Solar collectors

1979

**AN ANALYTICAL INVESTIGATION OF THE PERFORMANCE OF SOLAR COLLECTORS AS NIGHTTIME HEAT RADIATORS IN AIRCONDITIONING CYCLES.** Clay B. Jones and Frederick O. Smetana. Mar.1979. 60p.

**North Carolina Science and Technology Research Center, Research Triangle Park**  
**NASA NAS1-14208**

9 - 216304

Hill, James Edward, 1942-

Experimental verification of a standard test procedure for solar collectors / James E. Hill, John P. Jenkins, and Dennis E. Jones ; prepared for the Department of Energy, Research and Development Branch for Solar Heating and Cooling, Office of the Assistant Secretary for Conservation and Solar Applications. — Washington : U.S. Dept. of Commerce, National Bureau of Standards : for sale by the Supl. of Docs., U.S. Govt. Print. Off., 1979.

iv, 126 p. : ill. ; 27 cm. — (NBS building science series ; 117)

Includes bibliographical references.

I. Solar collectors--Testing. I. Jenkins, John P., joint author. II. Jones, Dennis E., joint author. III. United States. Dept. of Energy. Research and Development Branch for Solar Heating and Cooling. IV. Title. V. Series: United States. National Bureau of Standards. Building science series ; 117.

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**36142** (SAND-78-7035) Solar Collector Design and Fabrication Program. Final report. (Raytheon Co., Bedford, MA (USA). Missile Systems Div.). May 1978. Contract EY-76-C-04-0789. 193p. Dep. NTIS, PC A09/MF A01.

The report contains a detailed description of requirements, design and manufacturing of collector major components, including the mirrors, mirror support structure, absorber and its support structure, and the pedestal and drives. Numerous illustrations of the in-process and finished and installed equipment are included. Also included are the requirements for the collector control system, automatic and manual, as well as a description of a fluid circulating system to maintain delivered fluid temperature at a preselected value.

SIMPLE PROCEDURE FOR PREDICTING LONG TERM  
AVERAGE PERFORMANCE OF NONCONCENTRATING AND OF  
CONCENTRATING SOLAR COLLECTORS. M. Collares-  
Pereira and A. Rabl.

Solar Energy, vol 23, no 3, 1979, p. 235-253.

**Abstract** The Liu and Jordan method of calculating long term average energy collection of flat plate collectors is simplified (by about a factor of 4), improved, and generalized to all collectors, concentrating and nonconcentrating. The only meteorological input needed are the long term average daily total hemispherical insolation  $\bar{H}_h$  on a horizontal surface and, for thermal collectors the average ambient temperature. The collector is characterized by optical efficiency, heat loss (or  $U$ -value), heat extraction efficiency, concentration ratio and tracking mode. An average operating temperature is assumed. If the operating temperature is not known explicitly, the model will give adequate results when combined with the  $\phi$ ,  $f$ -chart of Klein and Beckman.

A conversion factor is presented which multiplies the daily total horizontal insolation  $\bar{H}_h$  to yield the long term average useful energy  $\bar{Q}$  delivered by the collector. This factor depends on a large number of variables such as collector temperature, optical efficiency, tracking mode, concentration, latitude, clearness index, diffuse insolation etc., but it can be broken up into several component factors each of which depends only on two or three variables and can be presented in convenient graphical or analytical form. In general, the seasonal variability of the weather will necessitate a separate calculation for each month of the year; however, one calculation for the central day of each month will be adequate. The method is simple enough for hand calculation.

Formulas and examples are presented for five collector types: flat plate, compound parabolic concentrator, concentrator with east-west tracking axis, concentrator with polar tracking axis, and concentrator with 2-axis tracking. The examples show that even for relatively low temperature applications and cloudy climates (50°C in New York in February), concentrating collectors can outperform the flat plate.

The method has been validated against hourly weather data (with measurements of hemispherical and beam insolation), and has been found to have an average accuracy better than 3 per cent for the long term average radiation available to solar collectors. For the heat delivery of thermal collectors the average error has been 5 per cent. The excellent suitability of this method for comparison studies is illustrated by comparing in a location independent manner the radiation availability for several collector types or operating conditions: 2-axis tracking versus one axis tracking; polar tracking axis versus east-west tracking axis; fixed versus tracking flat plate; effect of ground reflectance; and acceptance for diffuse radiation as function of concentration ratio.

INVESTIGATION OF A SOLAR HEAT COLLECTOR

T. Baimatov, U. Kh. Gaziev and T. Z. Abidov

Applied Solar Energy, vol. 15, no. 3, 1979, pp. 25-

38.

Four different versions of solar heat collectors (SHC) are experimentally investigated. The maximum equilibrium temperature of each version is determined, with both direct and concentrated solar radiation. The minimum equilibrium temperature of the SHC as a function of the size of the air gap between collector and transparent screen is established.

IEEE Circuits and Systems Magazine, Sept.  
v.1, no.3, 1979

CIRCUITS AND SYSTEMS CONCEPTS IN ENERGY RESEARCH.  
Special Issue.

18 MASTER CONTROL AND DATA ACQUISITION SYSTEM FOR A  
SOLAR CENTRAL RECEIVER ELECTRIC POWER PLANT

M.A. Soderstrand, D.M. Darvey, R.C. Rountree,  
R.R. Sheahan and C.P. Winarski

This paper describes the conceptual design arrived at through a U. S. Department of Energy sponsored two-year research and development program to design the 10 megawatt electric Solar Central Receiver Power Plant currently under construction in Barstow, California. The Circuits and Systems concepts related to the Master Control and Data Acquisition Systems are emphasized.

A7943677 # Orientation studies for single-axis concentrating collectors. S. Jeter, J. I. Craig, and E. G. Grems (Georgia Institute of Technology, Atlanta, Ga.). *Journal of Energy*, vol. 3, May-June 1979, p. 151-155. 6 refs.

The useful heat gain of a linear single axis concentrating solar collector is significantly affected by the orientation of the collector. The temporal distribution of the heat output, both diurnally and annually, and the integrated energy output vary with the direction of the collector axis. For a typical insolation sequence, a north to south orientation yields greater annual heat gain while an east to west orientation gives a flatter annual distribution. Selection of the best collector orientation depends on this distribution, the load profile, and the thermal capacitance of the system. The first two factors are considered in the definition of an economic criterion function which is then used to identify the optimum distribution of collectors among all possible orientations. A minimum value indicates a collector array optimized with respect to the characteristics of the load and the overall solar energy system. While applied here to a particular collector type, the method is general and can be used with other configurations. (Author)

DERIVATION OF METHOD FOR PREDICTING LONG TERM  
AVERAGE ENERGY DELIVERY OF SOLAR COLLECTORS.  
M. Collares-Pereira, and R. Rabl.

Solar Energy, vol 23, no 3, 1979, p. 223-233.

**Abstract** Based on the utilizability concept of Hottel, Whillier, Liu and Jordan, an analytical model has been developed to predict the long term average energy delivery of almost any solar collector. The presentation has been split into two separate papers: a users guide (without explanation of the origin of the formulas) and the present paper (which derives these formulas and documents the validation). The model is applicable whenever the average operating temperature of the collector (receiver surface, fluid inlet, fluid outlet or mean fluid) is known. If the operating temperature is not known explicitly the model will give adequate results when combined with the  $\phi_r$ -chart of Klein and Beckman. By contrast to the alternative of hour-by-hour simulation, prediction methods such as the present model and the  $\phi_r$ -chart offer the advantages of automatically averaging over year-to-year weather fluctuations and of being sufficiently simple to permit hand calculation of long term performance. In a comparison with hourly summations of insolation data, the present model has been found to have an error of less than 3 per cent for the radiation available to a solar collector and an error of about 5 per cent for the heat delivery of solar thermal collectors.

**N79 28762# Sandia Labs, Albuquerque, N. Mex  
OVERVIEW OF SOLAR SYSTEM DESIGN AND APPLICATION PRINCIPLES**

V. L. Dugan 1979 11 p. refs. Presented at the Solar Energy Symp., Tokyo, 5 Feb. 1979  
(Contract EY-76-C-04 0789)  
(SAND-78-2419C, Conf-790203-1) Avail: NTIS HC A02/MF A01

Solar thermal energy conversion systems represent a method of reducing dependency on stored energy reserves, this is done at the expense of an increased dependency on materials and land resources. The various technologies being investigated to convert solar radiation into thermal energy are reviewed, and general guidelines which should be followed in designing and applying cost-effective solar conversion systems are presented. This information is expanded upon and illustrated by a comparison of performance results for a range of solar thermal technologies and by one solar irrigation application in the United States DOE

**EFFECT OF OPTICAL SURFACE PROPERTIES ON HIGH-TEMPERATURE SOLAR THERMAL ENERGY CONVERSION.** L. Wen.

Journal of Energy, vol 3, no 2, Mar-Apr. 1979, p. 82-89.

The effects of thermal surface properties on the performance of representative point-focusing solar power plants are assessed in this paper. The tradeoff relationships are presented in terms of normalized system performance as a function of thermal optical design parameters. Crucial surface properties include solar reflectance, specular spreading due to microscopic roughness, surface error due to manufacturing slope tolerance or waviness, and concentrator pointing accuracy. Two representative power conversion systems, a Rankine steam cycle and an open-air Brayton cycle, are considered.

SEAMLESS SOLAR COLLECTOR, by Dan Ruby.  
Popular Science, vol. 214, no. 2, Feb. 1979, p.15

Conventional flat-plate solar collectors are heavy, fragile, and expensive to manufacture. And they're not the most graceful addition to a roof line. Now a one-piece, thermoplastic collector has been developed that may overcome these problems and make solar heating practical for more homeowners.

**MASTER CONTROL AND DATA ACQUISITION SYSTEM FOR A SOLAR CENTRAL RECEIVER ELECTRIC POWER PLANT.**  
M. A. Soderstrand and D. H. Darsey

IEEE Circuits and Systems, vol 1, no 3,  
September 1979. p. 18-27

This paper describes the conceptual design arrived at through a U. S. Department of Energy sponsored two-year research and development program to design the 10 megawatt electric Solar Central Receiver Power Plant currently under construction in Barstow, California. The Circuits and Systems concepts related to the Master Control and Data Acquisition Systems are emphasized.

**A80-18297 \* #** Advanced solar thermal receiver technology. A. A. Kudirka and L. P. Leibowitz (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0292.* 10 p. 6 refs. Research sponsored by the U.S. Department of Energy.

Development of advanced receiver technology for solar thermal receivers designed for electric power generation or for industrial applications, such as fuels and chemical production or industrial process heat, is described. The development of this technology is focused on receivers that operate from 1000 F to 3000 F and above. Development strategy is mapped in terms of application requirements, and the related system and technical requirements. Receiver performance requirements and current development efforts are covered for five classes of receiver applications: high temperature, advanced Brayton, Stirling, and Rankine cycle engines, and fuels and chemicals. (Author)



## MIRROR ENCLOSURES FOR DOUBLE-EXPOSURE SOLAR COLLECTORS

D. C. Larson

Solar Energy, vol. 23, no. 6, 1979, pp. 517-524.

**Abstract**—A conventional flat-plate collector panel can be employed in a double-exposure configuration when the panel is glazed on both sides and when mirrors are provided to reflect solar radiation onto the back side of the panel. In this paper, several flat-mirror configurations are evaluated and optimal configurations are determined for different solar energy applications at lat. 35, 40 and 45°. The various mirror configurations are evaluated theoretically by calculating direct-beam and diffuse solar radiation enhancement factors. The enhancement factors are defined as the ratio of the solar flux absorbed by both sides of a double-exposure panel to that absorbed by an identical single-exposure panel tilted at the latitude angle from the horizontal. The enhancement factors are calculated using the method of images and take account of the variation of glazing transmittance with incident angle. Optimal mirror configurations were determined for direct-beam solar radiation for both fixed-mirror configurations and adjustable-mirror configurations with semi-annual mirror rotations. Optimal fixed-mirror configurations were obtained for both winter space-heating and year-round applications. An adjustable-mirror configuration, however, was determined to be optimal for year-round solar collection and overall to be most adaptable to a variety of solar energy applications. The same adjustable-mirror configuration was determined to be optimal at all three latitudes and therefore a single design can be employed at diverse locations.

**A79-37847** The significance of longwave radiation in flat plate solar collector testing. A. A. Green and W. B. Gillett (University College, Cardiff, Wales). In: International Conference on Future Energy Concepts, London, England, January 30 February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 36-39. 15 refs.

While it is evident that the longwave radiative flux incident on the front surface of a flat plate solar collector can vary significantly and that such variations affect collector performance, the problems involved in its measurement remain disproportionately large in relation to the small effect it has on outdoor collector test results for incident solar fluxes greater than 600 W/sq m. Methods of accommodating variations in longwave flux in collector testing are discussed and the concept of environment resulting temperature is shown to be of value for its ability to accommodate not only variations in incident longwave flux but also variations in solar flux absorbed by a front transparent cover. B.J.

TECHNICAL NOTE, by A. Luque and E. Lorenzo, Solar Energy, vol. 22, no. 2, 1979, p.187-191.

TRANSMITTANCE OF DIFFUSE SOLAR RADIATION THROUGH A SERIES OF PARALLEL REGIONS.

Herein, results are presented graphically for the transmittance of isotropic and non-isotropic diffuse radiation through one-, two-, and three-glass plates for several relative orientations for the surface as a function of the sun's position in the sky.

A79-44557

The influence of environmental parameters on flat plate solar collector performance. A. A. Green (University College, Cardiff, Wales). In: Meteorology for solar energy applications; Proceedings of the Conference, London, England, January 24, 1979. (A79-44551 19-47) London, International Solar Energy Society, 1979, p. 95-107. 8 refs.

Results of computer modeling of single and double-glazed flat plate solar collectors are presented, in the form of conventional collector performance characteristics, indicating the influence of wind speed, ambient air temperature and effective sky temperature on collector steady state efficiency, for moderate values of other parameters. Variations in air temperature, and in wind speed for low wind speeds (less than 6 m/sec) are shown to have more significant effects than probable variations in effective sky temperature. The simplified computer models used in the investigation are described in an appendix. They are based on one-dimensional, steady-state heat transfer analyses of single- and double-glazed collectors and utilize recently published empirical results of convective heat transfer studies. The models take into account absorption of solar radiation by the transparent cover(s) and multiple reflection of solar radiation between the absorber plate and transparent cover(s) in a collector. (Author)

## SELECTIVE BLACK NICKEL COATINGS ON ZINC SURFACES BY CHEMICAL CONVERSION

P. K. Gogna and K. L. Chopra

Solar Energy, vol. 23, no. 5, 1979, pp. 405-403.

**Abstract**—An electrochemical conversion technique has been developed to deposit selective black nickel coatings of solar absorptance 0.90-0.94 and thermal emittance (at 100°C) 0.08-0.15 on galvanized iron, zincated, and zinc electroplated aluminium surfaces. The effect of electrochemical conversion parameters on the microstructure, optical and thermal properties and durability of the coatings has been established.

**N80-18557#** National Technical Information Service, Springfield, Va

**SOLAR ENERGY CONCENTRATOR DESIGN AND OPERATIONS. CITATIONS FROM THE NTIS DATA BASE Progress Report, 1976 - Jul. 1979**

Audrey S. Hundemann Sep 1979 183 p Supersedes NTIS/PS-78/0838 Updates NTIS/PS-77/0458 2 Vol (NTIS/PS-79/0926/0; NTIS/PS-78/0838) Avail: NTIS HC \$28.00/MF \$28.00 CSCL 10A

Government-funded research on the design and operation of various types of solar energy concentrators is discussed. Abstracts cover the efficiency and optimization of Fresnel lenses, V-trough concentrators, flat plate and parabolic reflectors, compound parabolic concentrators used in solar photovoltaic conversion, and heliostat systems. A few abstracts deal with heat loss and cost studies. (This updated bibliography contains 177 abstracts, 80 of which are new entries to the previous edition)

GRA



CALCULATION PRINCIPLES FOR HELIOSTAT FIELDS OF  
SOLAR POWER PLANTS

R. A. Zakhidov

Applied Solar Energy, vol. 15, no. 3, 1979, pp. 20-

The article offers a brief analysis of the current state of theoretical research into the concentrating systems of tower-type solar power plants. A need for developing a general design model is demonstrated. The basic framework of a theoretical model are presented, and formulas are derived for the irradiance on an arbitrary radiant-energy receiver from heliostats of arbitrary shape.

**N79-33570\*** Owens-Illinois, Inc., Toledo, Ohio.  
**OWENS-ILLINOIS SUBSYSTEM DESIGN PACKAGE FOR  
THE SEC-601 AIR-COOLED SOLAR COLLECTOR**  
Feb. 1979 19 p Prepared for DOE  
(Contract NAS8-32259)  
(NASA CR-161094) Avail NTIS HC A02/MF A01 CSCL  
10A

The subsystem design of the SEC 601 solar collector was evaluated. The collector is of modular design and is approximately 12 feet three inches wide and eight feet seven inches tall. It contains 72 collector tube elements and weighs approximately 300 pounds. Included in this report are the subsystem performance specifications and the assembly and installation drawings of the solar collectors and manifold.  
R E S

THE ANALYSIS AND COMPARISON OF ACTUAL TO PREDICTED  
COLLECTOR ARRAY PERFORMANCES. W.H. McCumber, M.W.  
Weston.

IBM Journal of research and Development, vol 23, no 3,  
May 1979, p. 240-252.

*The Hottel-Whillier-Bliss (HWB) equation has been the standard tool for the evaluation of collector thermal performance for four decades. This paper presents a technique that applies the criteria of ASHRAE Standard 93-77 to the determination of the HWB equation coefficients from field derived data. Results of the analysis of a sample collector array illustrate the technique. Actual dynamic performances of various collector arrays in the field are compared to those predicted by the steady-state efficiency models for the individual panels. In certain cases, the HWB model produces deviations of over 100% from measured hourly performances and 35% from measured monthly performances when compared with the single panel laboratory derived model. However, when the field derived HWB model is used as the basis of comparison the performance deviations were typically less than 5%.*

**N80 10640#** Sandia Labs, Albuquerque, N Mex  
**GRAPHICAL REPRESENTATION OF TMY SOLAR RADIATION AVAILABILITY FOR ONE AND TWO AXIS SOLAR COLLECTORS**

L L Lukens and R R Peters May 1979 113 p refs  
(Contract EY 76-C-04-0789)  
(SAND 79 0418) Avail NTIS HC A06/MF A01

Information about the availability of direct normal radiation to three tracking modes of concentrating collectors (two axis, east west, and north south horizontal axis tracking collectors) for the 26 typical meteorological year stations is presented. The data presented include energy availability, efficiency based on the direct normal radiation availability, and energy distribution.  
DOE

**N79 33561\*** Wyle Labs, Inc., Huntsville, Ala  
**INDOOR TEST FOR THERMAL PERFORMANCE OF THE  
SUNMASTER EVACUATED TUBE (LIQUID) SOLAR COLLECTOR**

Sep 1979 40 p Prepared for DOE  
(Contract NAS8 32036)  
(NASA-CR-161306; WYLE TR-531-30R) Avail NTIS  
HC A03/MF A01 CSCL 10A

The test procedures used to obtain the thermal performance data for a solar collector under simulated conditions are presented. Tests included a stagnation test, a time constant test, a thermal efficiency test, an incident angle modifier test, and a hot fill test. All tests were performed at ambient conditions and the transient effect and the incident angle effect on the collector were determined. The solar collector is a water working fluid type.  
A W H

**N80 11580#** Sandia Labs, Albuquerque, N Mex  
**CONCENTRATING SOLAR COLLECTOR TEST RESULTS  
COLLECTOR MODULE TEST FACILITY (CMTF) Summary  
Report, Jan. - Dec. 1978**

V E Dudley and R M Workhoven Mar. 1979 54 p refs  
(Contract EY 76-C-04-0789)  
(SAND 78 0977) Avail NTIS HC A04/MF A01

The results are summarized of tests on four concentrating solar collectors at output fluid temperatures from 100 C to 300 C.  
DOE

# THERMAL ANALYSIS OF SOME FLAT-PLATE SOLAR COLLECTOR DESIGNS FOR IMPROVING PERFORMANCE, by D.L. Siebers and R. Viskanta.

Journal of Energy, vol. 3, no. 1, Jan./Feb. 1979, p. 8-15.

The effects of suppression of thermal radiation, conduction and/or free convection heat loss from the absorber of a flat-plate solar collector are analytically studied. A two-dimensional, steady-state, heat-transfer analysis is developed for a collector for this purpose. The analysis accounts for the temperature gradients in the fluid flow and vertical directions in the collector, the collimated and diffuse nature of solar irradiation, the physical and thermodynamic properties of the materials in the collector, the number of cover plates, any selective surfaces, and the collector dimensions. The spectral nature of radiation heat transfer in the collector is modeled by two spectral bands, solar and thermal. The results illustrate that a single selective surface on the absorber or on the cover plate closest to the absorber to suppress thermal radiation heat loss is the most effective means of improving flat-plate collector performance when only suppressing one mode of heat transfer. Honeycomb structures placed in the air gap between the absorber and cover plate to suppress free convection or evacuation of the air gap to eliminate conduction and free convection are not as effective a method of improving collector performance as selective surfaces at higher ( $> 100^\circ\text{C}$ ) collector temperatures.

A79-32952 Contribution to the study of optimal conditions for optical concentration in solar power plant designs. Reduction of the radiation spot provided by a field of heliostats by use of optimized conical mirrors (Contribution à l'étude des conditions optimales de la concentration optique dans les projets de centrales solaires. Réduction de la tache de rayonnement fournie par un champ d'héliostats, au moyen de miroirs coniques optimisés). P. Malifaud (Paris VI, Université, Paris, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 21-33, 27 refs. In French.

The paper recalls the limit imposed on optical concentration by the second principle of thermodynamics and the Clausius relation. It is shown that the best optical instruments to attain this limit are conical or pyramidal mirrors. An application for a solar plant with heliostat field is examined. Data are given on the balance calculation of elementary flux through a conical mirror and the correct estimate of the losses coming from inner reflections. Technological information about proper materials giving a large reflective coefficient at high temperatures is provided. (Author)

A79-32955 Comparative efficiencies of solar energy collectors. M. Duban (Laboratoire de Technologie Optique, Marseille, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 57-66.

The geometric efficiencies of basic collector types are compared by examining the constancy of their collection of solar energy during a day or year, independent of their dimensions, amount of energy collected, concentration, and the use of the energy. Five basic types of collector are considered: the sun tracking collector, the flat plate collector, the fixed stepped cylindrical mirror, a collector rotating about an axis, and a fixed spherical mirror. A global comparison of these collectors is performed for all latitudes between 0 and 50 deg by 5 deg steps, for every month, and for the values 0 and 0.5 for the ratio of minimum power necessary for operation of the installation to the maximum power. P.T.H.

A79 43591 An efficient optical window for flat plate solar energy collectors. K. S. Kohli, K. N. Chopra, and R. Hradynah (Instruments Research and Development Establishment, Dehra Dun, India). *Journal of Optics*, vol. 10, May/June 1979, p. 137-139, 11 refs.

The design features and merits of a modified optical window for use in flat plate solar energy collectors are described. An optical window composed of two transparent acrylic plastic sheets ribbed together is considered. One of the inner surfaces of the solar window has triangular projection pairs, each of them being separated from the adjacent one by a distance equal to the width of the triangular projection pair at the top. The use of the triangular projection pairs provided in the modified design brings about a significant increase in the efficiency of the solar energy collector at large angles of incidence. Reduced Fresnel reflection losses occur when the solar radiation energy is transmitted through the modified optical window. It is concluded that the modified optical window assures reasonably high overall efficiency of the solar energy collector at and near zero degree angles of incidence and also improve it at large angles of incidence. S.D.

## EVACUATED HEAT PIPE SOLAR COLLECTOR F. Mahdjuri

Energy Conversion, vol 19, no. 4, 1979, pp. 85-90.

Abstract A tubular evacuated solar collector with rectangular performance characteristics is introduced. The heat transfer from the absorber plate with selective coating to the water tubing occurs via a heat pipe system. In order to avoid any delay in the operation of the heat pipe due to superheating of the vapour, we have introduced a trap mechanism for the condensed liquid. To avoid the disadvantage of the high no-load condition of the vacuum collectors we have used the physical features of the critical point of the heat pipe working fluid.

Above the critical temperature,  $T_c$  of the working fluid the condensation effect will disappear. This means that above  $T_c$  the heat transfer property of a heat pipe will vanish. This will cause only a slight increase of the condenser temperature above  $T_c$  of the liquid used. For our heat pipe system we have chosen working liquids with critical temperature between 95-115  $^\circ\text{C}$ .

A80 18570 # Design, evaluation, and testing of a moderately concentrating, non-tracking solar energy collector. A. Olivera and R. B. Bannerot (Houston, University, Houston, Tex.). *American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Dec. 27, 1979, Paper 79-WA/Sol-3*, 10 p. 33 refs. Members, \$15.00. Nonmembers, \$3.00.

The thermal performance of a moderately concentrating, non-tracking solar energy collector is predicted based on a series of experimental evaluations of its components. Four reflector designs were constructed and tested. Six simple tubular receiver designs and a collector utilizing one of the reflector designs and one of the receiver designs were constructed and tested. The predicted performance closely approximated the actual thermal performance of the collector. The component evaluations are discussed in detail, so that the analysis can be extended to other designs. (Author)

**LUMINESCENT SOLAR CONCENTRATORS. 1: THEORY OF OPERATION AND TECHNIQUES FOR PERFORMANCE EVALUATION. J. S. Batchelder, A. H. Zewail, and T. Cole**

Applied Optics, vol 18, no 18, September 15, 1979, p. 3090-3110.

Techniques and calculations are presented that give explicit expressions for the over-all performance of a luminescent solar concentrator (LSC) in terms of the intrinsic spectral response and quantum efficiency of its constituents. We examine the single dye (or inorganic ion) LSC with emphasis on the planar geometry. Preliminary data on the degradation of candidate LSC dyes under severe weathering conditions are also given. Armed with our experimental results and analysis of solar absorption, self-absorption, and solar cell efficiency, we present a new genre of solar concentrator with a theory of operation for the device.

**A79-51744** Solar collector as heat pump evaporator. S. Chaturvedi, A. S. Roberts, Jr. (Old Dominion University, Norfolk, Va.), and V. Mei (Illinois Institute of Technology, Chicago, Ill.). In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings. Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 99-104.

Thermal performance of a solar assisted heat pump is analyzed for various ambient conditions. In the proposed concept, bare collector also acts as evaporator for the heat pump. Results indicate that evaporator temperature 0 to 15C above ambient temperature can be maintained for wide ranging ambient conditions. Long term system performance of the system for Norfolk, Virginia indicates that payback period of 12 years is possible for a base electricity rate of \$0.06/kwhr, 10% fuel escalation rate and 8% interest rate. Payback period can be significantly reduced if the system is optimized and if the heat pump is also used for domestic water heating. (Author)

**A79-37848** The development and construction of a simulator for the proof testing of solar power devices. J. R. Laidler and G. R. Bainbridge (Newcastle-upon-Tyne, University, Newcastle-upon-Tyne, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 30-35, 13 refs.

Variables affecting collector performance are reviewed and the discussion focuses on the different types of solar radiation distributions. This information is then used to examine the principles of solar simulator construction, with attention given to direct radiation simulation, diffuse radiation simulation, and environmental simulation. The solar simulator at the Energy Centre in the University of Newcastle-upon-Tyne is briefly discussed. B.J.

**A80-18585 #** A comparison of test results for flat-plate water-heating solar collectors using the BSE and ASHRAE procedures. J. P. Jenkins and J. E. Hill (National Bureau of Standards, Washington, D.C.). American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Dec. 27, 1979, Paper 79-WA/Sol-4, 13 p. 10 refs. Members, \$1.50; nonmembers, \$3.00. Research sponsored by the U.S. Department of Energy.

Five solar collectors were tested according to the BSE and ASHRAE test procedures and the results compared. All five collectors tested were modular, flat plate, water heating, and included single- and double-glazed designs with and without selectively coated absorbers. In both procedures, collector efficiency curves are determined. The ASHRAE procedure consists exclusively of outdoor testing whereas the BSE procedure requires a combination of outdoor and indoor testing (no irradiation) to determine the collector's optical and thermal loss characteristics, respectively. During the indoor testing in this study, the environmental test conditions were controlled and regulated by use of specially built environmental simulators to investigate the effect of wind speed and 'sky' temperature on the thermal loss characteristics of the collectors. (Author)

**AIChE Symposium Series, v.75, 1979  
no.189.**

**HEAT TRANSFER - SAN DIEGO 1979. Robert W. Lyczkowski, ed. (Comprised of papers presented at AIChE 18th National Heat Transfer Conf. held San Diego, Calif., Aug.5-8,1979).**

**DYNAMIC SIMULATION AND DEVELOPMENT OF A CONTROL STRATEGY FOR A DISTRIBUTED CONCENTRATING SOLAR COLLECTOR FIELD.....F. F. Klein 291**

A simulation of a distributed solar collector field is developed to evaluate a proposed control concept. The simulation is designed to test whether the field temperature is acceptably controlled with various types of cloud cover. Relatively simple component descriptions are combined into a complex model. Selected simulation results are presented.

**A79-47795** Relation between concentration and acceptance in solar collectors. F. Grasso, F. Musumeci, and A. Triglia (Catania, Università, Catania, Italy). Solar Energy, vol. 22, no. 6, 1979, p. 521-525, 7 refs.

The maximum concentration ratio has been derived by Winston for optical systems having an angular acceptance described by a step function. In this paper a more comprehensive relation between maximum concentration ratio and angular acceptance is obtained. This relation is valid for any acceptance function; the proof is based on thermodynamics and is valid for large angles as well. The total energies collected yearly by concentrators having different acceptance functions are compared. (Author)

**PERFORMANCE OF AN INEXPENSIVE CONSTANT SOLAR COLLECTOR/STORAGE SYSTEM IN GROUND. M. S. Sodha, A. Srivastava, G. N. Tiwari.**

Energy Research, vol 3, no 4, October-December 1979 p. 379-387.

This paper presents an analysis of the performance of an inexpensive constant flow solar collector/storage system, which has been validated by experiments. The system consists of a network of pipes buried in the ground, the top surface of the ground being blackened by black board paint every year or so. The heat is extracted by flow of fluid in the pipes at a constant flow rate. It is seen that for a  $7 \times 10^{-4}$  m/s of the plane of heat retrieval and 8 l/min flow rate of water, the collection efficiency of the system is 20.0 per cent. The efficiency increases with flow rate and decreases with the depth of the plane of heat retrieval.

**A79-32951** Solar tower power plants - Optimization of the mirror field and application to the field scale effect (Les centrales électrosolaires à tour - Optimisation du champ de réflecteurs et application à l'effet de taille du champ). C. Mersier (Electricité de France, Département Essais, Chatou, Yvelines, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 1-20. 12 refs. In French.

A method for optimizing the design of the mirror fields of solar tower installations is proposed. Two characteristics of the mirror field are important in this method: the shape of the mirrors and their distribution. The distribution of the mirrors in the field is basically determined by orientation effects (the cosine effect), shadows, and the mirror technology. If the receiver losses are negligible, the shape of the field for a given terrain and tower depends only on the mirror surface. For nonnegligible receiver losses, the shape of the field depends strongly on the orientation of the reflected flux receiving surface. P.T.H.

**N80-19625\*** Acurex Corp. Mountain View, Calif. Alternate Energy Division.

**LOW COST POINT FOCUS SOLAR CONCENTRATOR. PHASE 1 Final Report**

E. V. Nelson, T. C. Derbidge, D. Erskine, R. A. Maraschin, W. A. Niemeyer, M. J. Matsushita, and P. T. Overly. 16 Mar. 1979. 260 p. Prepared for JPL (Contract JPL-955208).

(NASA CR 162839. JPL-9550-28. Acurex FR-79-340) Avail NTIS HC A12/MF A01 CSCL 10A

The results of the preliminary design study for the low cost point focus solar concentrator (LCPFSC) development program are presented. A summary description of the preliminary design is given. The design philosophy used to achieve a cost effective design for mass production is described. The concentrator meets all design requirements specified and is based on practical design solutions in every possible way. R.E.S.

**A79-47651 \*** A mobile apparatus for solar collector testing. G. B. Hotchkiss (Texas Instruments, Inc., Dallas, Tex.), F. F. Simon (NASA, Lewis Research Center, Cleveland, Ohio), and L. C. Burmeister (Kansas University, Lawrence, Kan.). *American Society of Mechanical Engineers, Design Engineering Conference and Show, Chicago, Ill., May 7-10, 1979, Paper 79-DE-5.6* p. 14 refs. Grant No. NSG-3087.

The design, construction, and operation of a mobile apparatus for solar collector testing (MASCOT) is described. The MASCOT is a self-contained test unit costing about \$10,000 whose only external requirement for operation is electrical power and which is capable of testing two water-cooled flat plate solar collectors simultaneously. The MASCOT is small enough and light enough to be transported to any geographical site for outdoor tests at the location of collector usage. It has been used in both indoor solar simulator tests and outdoor tests. (Author)

**A79-36634** Practical design considerations for CPC solar collectors. A. Rabl (Argonne National Laboratory, Argonne, Ill.), N. B. Goodman, and R. Winston (Chicago University, Chicago, Ill.). *Solar Energy*, vol. 22, no. 4, 1979, p. 373-381. 25 refs. ERDA-supported research.

Several practical problems are addressed which arise in the design of solar collectors with compound parabolic concentrators (CPC's). They deal with the selection of a receiver type, the optimum method for introducing a gap between receiver and reflector to minimize optical and thermal losses, and the effect of a glass envelope around the receiver. This paper also deals with the effect of mirror errors and receiver misalignment, and the effect of the temperature difference between fluid and absorber plate. The merits of a CPC as a second stage concentrator are analyzed. (Author)

**N79-33568\*** Wyle Labs., Inc., Huntsville, Ala. Solar Energy Systems Div.

**INDOOR TEST FOR THERMAL PERFORMANCE OF THE GE TC 100 LIQUID SOLAR COLLECTOR EIGHT- AND TEN-TUBE CONFIGURATION**

Sep. 1979. 47 p. Prepared for DOE

(Contract NAS8-32036)

(NASA CR-161305. WYLE-TR-531-36R)

Avail. NTIS

HC A03/MF A01 CSCL 10A

The thermal performance of a liquid solar collector was tested in eight- and ten-tube configurations under simulated conditions. A time constant test and an incident angle modifier test were also conducted to determine the transient and incident angle effects on the collector. Performance loss with accessory covers is demonstrated. The gross collector area is about 17.4 ft<sup>2</sup> sq without manifold and 19.1 ft<sup>2</sup> sq with manifold. The collector weight is approximately 60 pounds empty and 75 pounds with manifold. K.L.

**A79-38181** Solar collector sizing and design - An overview. J. R. Howell (Texas University, Austin, Tex.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0975*. 8 p. 8 refs.

A method for predicting the performance of flat plate solar energy collectors is presented. The derivation is based on the assumptions of the Hottel-Whillier-Bliss method (1958; 1959); however, the present approach is more closely related to conventional heat transfer analysis. The local and overall energy gain of the collector are found in terms of the inlet fluid temperature. The modified approach gives results directly comparable to those obtained by the effectiveness-number of transfer units method, and are in acceptable agreement with experiment. The efficiency and cost ratio curves of five collector types are given and their use in selecting a collector for a given application is discussed. C.K.D.

**N80-10558\*** National Technical Information Service. Springfield, Va.

**SOLAR ENERGY CONCENTRATOR DESIGN AND OPERATIONS. CITATIONS FROM THE ENGINEERING INDEX DATA BASE Progress Report, 1970 - Jul. 1979**

Audrey S. Hundemann. Sep. 1979. 225 p. Supersedes NTIS/PS-78/0839. Updates NTIS/PS-77/0459. 2 Vol.

(NTIS/PS-79/0927/8. NTIS/PS-78/0839) Avail. NTIS HC \$28.00/MF \$28.00 CSCL 10A

Worldwide research on the design and operation of various types of solar energy concentrators is discussed. Topic areas cover thermal and optical performance of Fresnel lenses, compound parabolic concentrators, fixed mirror concentrators, and planar reflector enhancement of flat plate collector systems. A few abstracts deal with V-trough concentrators and methods to calculate performance of concentrators. A separate Published Search on heliostat systems is available. This updated bibliography contains 220 abstracts, 53 of which are new entries to the previous edition. GRA

A79-53490 Optimization of a fixed solar thermal collector. J. D. Garrison (San Diego State University, San Diego, Calif.). *Solar Energy*, vol. 23, no. 2, 1979, p. 93-102. 11 refs.

Criteria are presented for optimizing solar thermal energy collection. These criteria are then used in setting the design of a fixed solar thermal energy collector. This design is obtained by proceeding carefully through a series of optimization steps. While seeking near optimum performance, features have been retained which should lead to low cost. Initial optimization steps lead to an all glass vacuum collector tube whose side and lower walls are internally silvered to provide optimal Winston concentration on an interior glass tube coated with a selective absorber. Heat transfer calculations, performed for an array module of these collector tubes, produce values for the radiation, heat conduction and pumping losses and indicate operating conditions which minimize these losses. Near this minimum, heat conduction and pumping losses are small and can usually be neglected. Liquids provide much better heat transfer than gases. (Author)

# **SOLAR COLLECTOR MANUFACTURING ACTIVITY, JULY 1977 THROUGH JUNE 1978.**

*Solar Heating & Cooling*, v.4, no.3, Apr.1979, p.7-

OC Physics of thin films : advances in research  
171 and development. v. 10 / edited by George  
.P3 Hass, Maurice H. Francombe. -- New York :  
v.10 Academic Press, 1979.  
RR xi, 324 p. : ill.

Spectrally Selective Surfaces for Photothermal  
Solar Energy Conversion

*R. E. Hahn and B. O. Seraphin*

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II. Fundamentals of Photothermal Solar Energy Conversion .....	4
III. Physical Processes and Materials Systems for Spectrally Selective Surfaces ....	28
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*SAMPE Quarterly*, v.10, no.1

Oct.  
1978

# **MATERIALS APPLICATIONS IN ADVANCED ENERGY SYSTEMS. Special Issue - 10th Anniversary Issue).**

**SPECULAR MIRRORS FOR SOLAR ENERGY APPLICATION .....**

54

**THE DEPENDENCE OF OPTICAL PROPERTIES ON THE STRUCTURAL COMPOSITION OF SOLAR ABSORBERS: GOLD BLACK,**  
by P. O'Neill, A. Ignatiev and C. Doland.  
*Solar Energy*, vol. 21, no. 6, 1978, p. 465-468.

Recent interest in the utilization of solar energy has prompted this investigation into an understanding of the basic physical concepts underlying the absorption of solar radiation by a material. Materials known as "solar blacks" (gold black, carbon black, and many others) have been classically used as good solar absorbers[1]. These materials, generally stable only below ~300°C, are noted for their extremely low reflectivity throughout the solar spectrum,  $R < 1$  per cent, and yet they are absorptive enough to provide complete extinction within a few microns of material. The basis for such ideal optical properties lies in the particulate, low density nature of the films[2]. However, the precise dependence of absorptance on microscopic structure is unknown.

The analysis of the dependence of solar absorptance on absorber microscopic structure has been undertaken for a test solar black: gold black. The information obtained will be useful in the development of a high-temperature stable solar absorber through the concept of modifying the surface morphology of a material so as to obtain the optimal structural properties for maximum solar radiation absorption.

**TECHNICAL NOTE, APPROXIMATIONS TO THE CPC-A COMMENT ON RECENT PAPERS BY CANNING AND BY SHAPIRO,** by M. Collares-Pereira, J. O'Gallagher and A. Rabl.  
*Solar Energy*, vol. 21, no. 3, 1978, p. 245-246

The purpose of this note is to clarify the issues involved in approximating the compound parabolic concentrator (CPC)[1-3] or other "ideal" concentrators (e.g. asymmetric ideal concentrators[4]) by non-ideal reflector shapes. Errors in recent articles by Canning[5] (see Gurnee[6]) and Shapiro[7] show that some misconceptions persist.

SOLAR CONCENTRATING PROPERTIES OF TRUNCATED  
HEXAGONAL, PYRAMIDAL AND CIRCULAR CONES.

Donald G. Burkhard, George L. Strobel, &  
David L. Shealy

Applied Optics, Vol. 17, No. 15, August 1,  
1978, p. 2431-2449.

In this paper we study the solar concentrating properties of specularly reflecting truncated pyramidal, hexagonal and circular cones. The first two configurations pack well for easy transportation and assembly, and when used multiply provide uniform coverage of the collector area. For most effective use, the symmetry axis of the cones will be pointed toward the sun. We are also interested, however, in the performance of the cones when the pointing is imperfect. For this purpose we define the direction of the solar rays by a polar angle  $\theta$  (or  $\gamma$ ) and azimuthal angle  $\phi$  with respect to the normal of the aperture of the cones as shown in Fig. 1. The irradiance at the base of the cone will depend upon the half angle  $\alpha$  between two opposite sides of the cone when the sides are extended to their point of intersection and also upon the maximum number of reflections,  $N$  that take place within the cone before the rays reach the base.

PLANAR SOLAR ENERGY CONVERTER AND CONCENTRATOR  
BASED ON URANYL-DOPED GLASS.

Nature, v.274, July 1978 13th, p.144-145.

A MAJOR improvement of solar cell efficiency is described here which uses a fluorescent plane glass to convert and concentrate the ultraviolet (UV) and blue part of the solar spectrum, thus increasing the possibilities of photovoltaic solar energy conversion. An advantage of our device is that the heat energy coming directly from the Sun will be dissipated over the large area of the glass and only the energy in the visible part of the spectrum will reach the solar cell. Moreover, the excess between the absorbed and band-gap energy which is evolved as heat in the solar cell will be diminished by decreasing the difference in wavelength between the useful and excess energy, and thus the solar cell will be heated to a much lesser extent.

FLUORESCENT SOLAR ENERGY COLLECTORS: OPERATING  
CONDITIONS WITH DIFFUSE LIGHT.

A. Gowitzberger

Applied Physics, Vol. 16, No. 4, August 1978,  
p. 399-404.

Recently the advantages of employing fluorescence phenomena for solar energy conversion were outlined [1,2]. It was shown in [1] that by using several collector plates in series the solar spectrum could be subdivided into different energy fractions and fed into solar cells adapted for these wavelengths. Surprisingly high conversion efficiencies appear theoretically possible. As was put forth in our previous publication, substantial experimental difficulties have to be overcome before a practical application of these collectors can be envisioned. These practical problems are not the subject of the present paper. Rather, some newer considerations will be presented here demonstrating even more favorable results than the preceding paper by taking conditions under diffuse light into account. Also the heat retained in a collector will be estimated. Other geometrical shapes of collectors will be evaluated and finally an error in [1] corrected.

PERFORMANCE ANALYSIS OF A PANCAKE ABSORBER-HELICAL  
HEAT EXCHANGER FOR A SOLAR CONCENTRATOR.

W.S. Duff.

J. Engineering Power, v.100, no.1, Jan.1978, p.178-81.

*This paper presents an analysis of the performance of a pancake absorber with a helical heat exchanger for use with point focus solar concentrating collectors. The principal difference between this type of absorber and most other concentrating solar collector absorbers is that the intensity of concentrated radiation monotonically increases from the inlet to the outlet of the heat exchanger tube. A performance expression for this absorber type and radiation distribution is derived and used to calculate thermal performance for several different absorber designs. Thermal performance for these designs is then calculated using a performance analysis based on the simplifying assumption that the heat exchanger tube is uniformly irradiated and the two performances are compared. The comparison indicates that the different radiation distribution assumptions lead to different absorber design choices. In particular, the simplifying assumption overstates thermal losses for increases in absorber size.*



TECHNICAL NOTE, OPTICAL PROPERTIES OF COMPOUND CIRCULAR ARC CONCENTRATORS, by R. E. Jones, Jr. and G. C. Anderson  
Solar Energy, vol. 21, no. 2, p. 149-151, 1978

Solar radiation concentrators may be divided into focusing and non-focusing types. Focusing concentrators, such as the familiar parabolic dish or cylinder, produce a point or line image with a high degree of concentration. The chief disadvantages are that they require continual tracking to follow the sun, and that they do not collect diffuse radiation. Non-focusing concentrators, on the other hand, accept radiation over a range of angles. For appropriately designed cylindrical non-focusing concentrators, with the long axis oriented east-west, diurnal tracking is not required and only occasional tilt adjustments are necessary. Also, significant diffuse radiation can be collected. A number of cylindrical reflector-type concentrators have been considered. Perhaps the most significant is the compound parabolic concentrator (CPC) [1-3]. Many of the others, such as the V-trough, compound circular arc, and elliptical, may be considered as approximations to the CPC. The resulting reduced optical performance, however, may be offset by fabrication advantages. For example, the compound circular arc concentrator or CCAC can be manufactured using standard sheet metal rollers. The optical properties of the CCAC have been discussed briefly by Shapiro[4], but unfortunately some of the results appear to be inaccurate. We present here a more complete analysis of the optical properties of the CCAC and compare them with those of the CPC.

NATURAL CONVECTION IN COMPOUND PARABOLIC CONCENTRATORS: A FINITE ELEMENT SOLUTION.  
S.I. Abdel-Khalik, et al.  
J. Heat Transfer, v.100, no.2, May 1978, p.199-204.

*Natural convection heat transfer coefficients between absorber surfaces and cover plates for vertically oriented two-dimensional compound parabolic concentrators (CPC) are evaluated using finite-element techniques. Values of the critical Rayleigh number for different concentrations ( $2 < C < 10$ ) with 1/3, 2/3, and full CPC heights are determined. Generalized charts for estimating the average absorber plate Nusselt number as a function of Rayleigh number and concentration for both full and truncated CPC cavities are given. The results are useful for evaluating the convective loss coefficients from such collectors.*

A CASE STUDY OF AN AIR HEATING COLLECTOR.  
Lewis Elwood  
Alternative Sources of Energy, No. 32, June 1978, p. 18-20

A NOVEL SOLAR COLLECTOR, by Y. Caouris, R. Rigopoulos, J. Tripanagnostopoulos and P. Yianoulis  
Solar Energy, vol. 21, no. 2, 1978, p. 157-160

Conventional flat solar thermal collectors are designed to use the greenhouse effect. They consist of an enclosed black absorbing surface covered by one or more transparent plates. The fluid which is heated, usually water or antifreeze solution, circulates below the black absorbing surface.

In the collector we propose the working fluid (liquid) circulates above the absorbing surface, and absorbs the IR radiation which is emitted by it. There is therefore no need for a selective black surface. It is useful to examine the conditions under which the proposed collector performs better than the conventional ones.

The same approach has been proposed for Solar air heaters[1]. However since the reflective losses from such an air heater are increasing with the number of layers used, we cannot use, efficiently, more layers in order to achieve higher temperatures.

TJ  
R10  
W44

Welford, W. T.

The optics of nonimaging concentrators : light and solar energy / W. T. Welford, R. Winston. — New York : Academic Press, 1978.

xi, 200 p. : ill.

Includes bibliographical references and index.

ISBN 0-12-745350-1

1. Solar collectors. I. Winston, Roland, joint author. II. Title.

A78-19831

Asymmetrical non-imaging cylindrical solar concentrators. D. R. Mills and J. E. Giutronich (New South Wales, University, Kensington, Australia). Solar Energy, vol. 20, no. 1, 1978, p. 45-55. 8 refs.

Two types of asymmetrical concentrators, parabolic and non-parabolic, are compared to those with symmetrical designs. Asymmetrical configurations are found to provide many advantages, including: (1) a concentration versus time-of-day relationship which can compensate for projected solar-area fall-off, allowing more uniform energy output when this is desirable, (2) greater operational flexibility, (3) easier adaptation to vacuum-insulated receivers, and (4) possible increased concentration and energy collection per unit of mirror area for systems with receivers which can make use of the large daily changes in energy input. It is noted that although a higher tracking frequency may be required, a tilting adjustment every few days will provide adequate compensation.

S.C.S.

AMORPHOUS SILICON AS A SELECTIVE ABSORBER  
OF SOLAR ENERGY: A SPECTRAL EMISSIVITY STUDY.

J. O. White, T. R. Kirst, & J. Tauc  
Applied Optics, Vol. 17, No. 15, August 1,  
1978, p. 2427-2430.

The efficiency of selective absorbers such as those used in some high temperature photothermal solar energy conversion systems can be calculated if the optical constants of the materials at the operating temperature are known. A study of crystalline and amorphous silicon based on the measurements of optical transmission was recently reported.<sup>1</sup> An alternative method, based on measuring thermal emissivity, is described in this paper. The absorption losses in the ir region from  $3\text{ }\mu\text{m}$  to  $6.3\text{ }\mu\text{m}$  within the  $400\text{--}800^\circ\text{C}$  temperature range were determined by emission spectroscopy techniques. Amorphous silicon films were used in the present work for two reasons: First, studies on the same films were already carried out; this enabled a comparison of the present results with those obtained by another method. Second, the residual absorption found in this region by the transmission method<sup>1</sup> is of high interest, since it seriously decreases the efficiency of the selective absorber. It is probably related to the high impurity content in our amorphous Si films which is likely responsible for the unusually high stability of these films against crystallization.<sup>2</sup>

AUGMENTED SOLAR ENERGY COLLECTION USING DIFFERENT  
TYPES OF PLANAR REFLECTIVE SURFACES; THEORETICAL  
CALCULATIONS AND EXPERIMENTAL RESULTS, by D.P.  
Grimmer, K.G. Zinn, K.C. Herr and B.E. Wood.  
Solar Energy, vol. 21, no. 6, 1978, p. 497-501.

In this paper we shall present results of theoretical calculations and experimental tests on the use of different types of flat reflective surfaces (specular, diffuse, and combination specular/diffuse) to increase the collector performance with such a reflector[4].

SELECTIVE ABSORPTION OF SOLAR ENERGY IN GRANULAR  
METALS: THE ROLE OF PARTICLE SHAPE.

C. G. Granqvist & O. Hunderi  
Applied Physics Letters, Vol. 32, No. 12,  
June 15, 1978, p. 798-800.

Coatings for efficient photothermal conversion of solar energy should have high absorption at wavelength  $\lambda < \lambda_c$  and low absorption at  $\lambda > \lambda_c$ , where  $\lambda_c$  is  $\sim 2\text{ }\mu\text{m}$ . For granular metals, we show by computation that  $\lambda_c$  depends strongly on the shape of the metal particles. Increasing eccentricity of ellipsoidal grains is seen to displace  $\lambda_c$  towards the infrared. A similar shift is found also for spherical metallic shells surrounding dielectric cores of increasing size. Some implications for practical absorber surfaces are pointed out.

EFFECT OF SUBSTRATE ON GRAPHITE AND OTHER  
SOLAR SELECTIVE SURFACES.

D. R. McKenzie  
Applied Optics, Vol. 17, No. 12, June 1978, p.  
1884-1888

In this paper some considerations which govern the choice of substrate metal in a single layer solar selective absorbing surface are discussed. The single layer surfaces considered here consist of a metal substrate of low emittance overcoated with a uniform layer of another material of such a thickness as to produce solar absorptance by interference. This is the simplest type of selective surface and lends itself to detailed analysis. The first part of the paper is concerned with the choice between the representative metals, copper, silver, and nickel, on performance considerations alone. Copper is a low emittance metal with strong visible absorptance, silver is a metal of low emittance with very small visible absorptance, while nickel is a metal of higher emittance with moderate visible absorptance. The index of performance used is the power available, after allowing for radiative losses, from  $1\text{ m}^2$  of the surface exposed to  $1\text{ kW}$  of incident flux. The index is, of course, a function of the operating temperature, which must be specified.



**EVACUATED-TUBE SOLAR COLLECTOR: EFFECT OF CONTROL ON EFFICIENCY AT HIGH OPERATING TEMPERATURE**

William C. Louie and David C. Miller

ASHRAE Journal, vol. 20, no.5, May 1978, p. 39-42

*Data are presented illustrating the operation of an evacuated-tube solar collector mounted on the penthouse of SH&G headquarters in downtown Detroit, Michigan. Problems in retaining system efficiency at elevated operating temperatures point to the importance of systems control strategy.*

**A SIMPLE PLATE CLUTCH FOR SOLAR CONCENTRATORS.**

A. Thomas, M. Ramakrishna Rao, & T. V. Pardhasaradhi

Journal of the Indian Institute of Science,  
Vol. 60, No. 5, May 1978, p. 267-269.

Design and constructional aspects of a simple plate clutch used for solar

concentrators are described.

- TJ International Symposium-Workshop on Solar  
#10 Energy, Cairo, 1978.  
.I73 International Symposium-Workshop on  
1978 Solar Energy : [symposium lectures], 16-  
22 June 1978, Cairo, Egypt / presented by  
Clean Energy Research Institute, University  
of Miami, Florida ; sponsored by National  
Science Foundation ; edited by T. Nejat  
Veziroglu, Homer W. Miser. -- [s.l.:s.n..

**SOLAR COLLECTORS PART I - FUNDAMENTALS, COLLECTORS OF THE PAST AND PRESENT**

M. K. Selcuk, Jet Propulsion Laboratory, Pasadena, California,  
U.S.A.

**SOLAR COLLECTORS PART II - RECENT DEVELOPMENTS AND FUTURE PERFORMANCE DATA AND ECONOMIC ANALYSIS**

R. K. Collier, Los Alamos Scientific Laboratories of the  
University of California, Los Alamos, New Mexico, U.S.A.

TA National SNET Symposium and Exhibition, 23rd,  
#10.9 Anaheim, Calif., 1978.

.C6 Selective application of materials for  
A3 products and energy ... c1978.  
1978 (Card 2)

Includes bibliographical references and  
index.

1. Materials--Congresses. I. Society  
for the Advancement of Material and Process

SUITABLE OPTICAL MATERIALS FOR SOLAR COLLECTOR APPLICATIONS 375

J. E. Gilligan and J. Brzusiewicz

TA National SNET Symposium and Exhibition, 23rd,  
#10.9 Anaheim, Calif., 1978.

.C6 Selective application of materials for  
A3 products and energy ... c1978.  
1978 (Card 2)

Includes bibliographical references and  
index.

1. Materials--Congresses. I. Society

THE THERMO-MECHANICAL BEHAVIOR OF POLYVINYL BUTYRAL FILM 186  
AND ITS EFFECT ON FOCAL STABILITY OF A SOLAR MIRROR-LAMINATE

A. M. Lindrose and T. R. Guess

**HOW TO BUILD YOUR VERY OWN SUN SUCKER!**

Eric Larson

Alternative Sources of Energy, No. 32, June  
1978, p. 14-15

Early in our housing program we decided to  
build a simple solar collector to use as an "add-on"  
heating aid. The design selected was purposely  
basic, even though a marginally fancier collector  
should have produced substantially greater bene-  
fits.

**THERMAL CONVERSION OF SOLAR RADIATION, THEORETICAL PERFORMANCE OF COLLECTORS FURNISHED WITH AN ABSORBENT SELECTIVE SURFACE**, by R. Pasquetti and F. Papini  
Solar Energy, vol. 21, no. 2, 1978, p. 29-38

**Abstract**—The present study is concerned with the determination of the behavior of selective surfaces in thermal converters of solar energy. By means of an idealized model, the influence of various parameters such as selectivity, concentration ratio and working temperature on the efficiency of the collector is thus brought out. The study leads to an optimised selective surface for each condition of use, either by considering the instantaneous efficiency or, in a more realistic way, by introducing the daily efficiency of an installation. Furthermore, a "temperature-concentration" diagram allows us to make an *a priori* estimation of the suitable value of the selectivity if the temperature and the concentration ratio are externally determined. It is also shown how convective phenomena have to be taken into account in the establishment of the characteristics of the collector.

**THE OPTIMAL ENERGY DESIGN OF STRUCTURES BY USING THE NUMERICAL SIMULATION OF THE THERMAL RESPONSE - WITH EMPHASIS ON THE PASSIVE COLLECTION OF SOLAR ENERGY.**  
A. F. Emery, D. R. Heerwagen, C. J. Kippenhan, S. V. Stoltz, & G. B. Varey  
Energy and Buildings, Vol. 1, No. 4, June 1978, p. 367-382

*The paper describes the development of such a calculational program as part of the work of a team of architects, climatologists, and engineers who have been working on the task of incorporating and executing conserving designs in the medium size group residential structures. The responsiveness of the program to the needs of the users and the demonstration of its accuracy is illustrated by several computational examples of single and multi-room configurations. The effects of typical design choices and changes are illustrated by calculations for short time summer and winter extreme weather conditions and also for long time average weather behavior. Both modeled and actual weather data are used in these calculations.*

**THERMAL OPTIMIZATION OF COMPACT SOLAR WATER HEATERS.**

A. Bar-Cohen

Solar Ener., v.20, no. 2, 1978, p193-196.

Compact solar heaters, incorporating the storage volume and collector in a single, shallow unit, are one attractive alternative to thermosyphon systems. The elimination of the vertical storage tank in the compact units could markedly reduce the cost of solar water heating and may well remove aesthetic objections to roof-top installations. Most compact heaters and particularly the inclined tank configuration shown in Fig. 1, offer highly efficient solar energy conversion during periods of abundant insolation, but their overall performance is adversely affected by significant night-cooling due to the absence of a separate fully-insulated storage tank[1,2]. The use of removable, collector plate insulation or tank draining during the night[1] can partially alleviate this situation, but it appears preferable to base compact solar heater development on the thermal optimization of the storage volume to collector area ratio. This optimization can often provide the desired end-of-night storage temperature for given climatic conditions and collector characteristics. The present effort focuses on such an optimization, subject to the limitation of a single end-of-night water draining period, and assumes that an auxiliary heat source is available for periods of inclement weather and for heavy hot water demand.

**AN APPROXIMATE EQUATION FOR PREDICTING THE SOLAR TRANSMITTANCE OF TRANSPARENT HONEYCOMBS,**

by K.G.T. Hollands, K.N. Marshall and R.K. Wedel  
Solar Energy, vol. 21, no. 3, 1978, p. 231-236

**Abstract**—An approximate equation is presented for predicting the solar transmittance of transparent honeycombs. The method accounts for scattering which occurs in such honeycombs by introducing diffuse components for both the reflectivity and transmissivity of the honeycomb wall. Required inputs to the equation are the optical properties of the honeycomb wall material, averaged over the solar spectrum. Methods of determining these properties are described. Although strictly applicable to a square-celled honeycomb, the equation should be approximately valid for hexagonal honeycombs as well. The equation is compared to the measured transmittance of a hexagonal-celled Lexan honeycomb with good results.

N78-24814\*// Wyle Labs., Inc., Huntsville, Ala. Solar Energy Systems Div.

**OUTDOOR THERMAL EFFICIENCY EVALUATION OF THE YING SOLAR COLLECTOR**

14 Mar. 1978 17 p ref Revised Prepared for DOE  
(Contract NAS8-32036)

(NASA-CR-150675; WYLE-TR-531-21-Rev-A) Avail: NTIS HC A02/MF A01 CSCL 10A

The test procedure used and the test results obtained during an evaluation test program to obtain thermal efficiency performance data are presented. The flat plate collector used water/ prestone antifreeze solution as the working fluid. Author

**AN ANALYTIC EVALUATION OF THE FLUX DENSITY DUE TO SUNLIGHT REFLECTED FROM A FLAT MIRROR HAVING A POLYGONAL BOUNDARY**, by F. W. Lipps and M. D. Walzel

Solar Energy, vol. 21, no. 2, 1978, p. 113- 21

**Abstract**—Computer algorithms for the flux density of reflected sunlight from a heliostat become an essential part of the optical simulation problem for the central receiver system. An exact analytic result is available for heliostats having polygonal boundaries. An analytical method for round heliostats is given in Appendix A, which is extremely complex and requires quartic roots. A useful numerical method is given in Appendix B for heliostats of arbitrary shape. A comparison is made between the analytic method and the Hermite function method, which is much faster but less accurate. The analytic method provides a basis for evaluating all other flux density calculations.

**OPTIMAL GEOMETRIES FOR ONE- AND TWO-FACED SYMMETRIC SIDE-WALL BOOSTER MIRRORS**, by D. D. Mannan and R. B. Bannerot.

Solar Energy, vol. 21, no. 5, 1978, p.385-391.

In this paper two trough-like (infinitely long) east-west aligned collectors are discussed. A thermal absorber or possibly solar cells are located at the base of the trough. Seasonal tilt adjustments occur about the east-west axis. The side walls are symmetric about the plane normal to the base. One collector type utilizes a single plane reflector on each side; the other, two plane reflectors. The two configurations are illustrated in cross section in Fig. 1.

**SPECULAR MIRRORS FOR SOLAR ENERGY APPLICATION**, by H. Taketani and W. M. Arden.

Sampe Quarterly, vol. 10, no. 1, October 1978, p. 54-63.

The reflectance efficiency of heliostat mirror surfaces is a critical parameter in the central tower concept for conversion of solar energy. Reflectance efficiency was measured on silver coated surfaces and on second-surface mirrors of float and sheet glass for comparison in a solar heliostat. Abrasion tests were conducted to determine the effect of impingement of sand particles on the reflectance of the heliostat mirror. Washing studies were performed to identify the most effective solution and cleansing procedure for the heliostat surfaces.

**TECHNICAL NOTE, EFFECT OF SURFACE CURVATURE ON MEASUREMENT OF THE ABSORPTANCE PROPERTIES OF SOLAR COATINGS**, by R. B. Pettit

Solar Energy, vol. 21, no. 3, 1978, p. 247-248

Because optical instrumentation used to characterize solar coatings is most often designed to accommodate flat samples, special calibration procedures must be developed in order to accurately measure the optical properties of coatings applied to curved surfaces. These procedures were developed for the measurement of the spectral hemispherical reflectance for coatings applied to circular receiver tubes using an integrating sphere reflectometer. The accuracy of the measured reflectance values depends upon the optical characteristics of the reflectometer and the coating studied. However, by using thin, opaque calibration materials attached to the tubes, the accuracy of the reflectance values can be easily determined or compensated for in the measurement. This procedure has also been applied to emittance measurements of coatings applied to curved surfaces using an IR reflectometer.

**FLEXIBLE ALUMINIZED WALL WINS ARCHITECTURAL AWARD.**

Solar Heating and Cooling, Vol: 3, No. 4, August 1978, p. 7.

Flexible aluminized wall serves as solar collector in architectural award design.

**AIR HEATING COLLECTORS -- SIMPLIFIED.**

Lewis A. Elwood

Alternative Sources of Energy, No. 32, June 1978, p. 21-23

**THE WINSTON SOLAR CONCENTRATOR IS NOT AN ELLIPTICAL CONCENTRATOR**

R.E. Jones

Solar Ener., v.20, no.2, 1978, p.179.

A78-31480

The first year of solar collector testing at Ontario Research. R. W. Bertram and G. Norgate (Ontario Research Foundation, Mississauga, Canada). In: Renewable alternatives: Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 2. (A78-31401 12-44) Winnipeg. Solar Energy Society of Canada, Inc., 1978. 16 p. 8 refs.

THE MEASUREMENT OF OPTICAL PROPERTIES OF SELECTIVE SURFACES USING A SOLAR CALORIMETER, by H. Willrath and R. B. Gammon  
Solar Energy, vol. 21, no. 3, 1978, p. 193-199

**Abstract**—An instrument has been constructed to measure the solar absorptivity and IR emissivity of surfaces using calorimetric methods to determine their selectivity and hence their possible use in solar energy devices. Absorptivity and total hemispherical emissivity can be calculated as a function of temperature by measuring respectively, the rate at which a thermally isolated sample in an evacuated chamber increases in temperature when exposed to real or simulated sunlight, and the rate at which it cools when shaded. These parameters can be used to compare the relative efficiencies of different surfaces at various operating temperatures.

CALCULATION OF FLAT-PLATE COLLECTOR UTILIZABILITY, by S. A. Klein.  
Solar Energy, vol. 21, no. 5, 1978, p. 393-402.

**Abstract**—The "utilizability" or  $\phi$ -curve method developed by Whillier[1] and later generalized by Liu and Jordan[2, 3], can be a very useful design tool for some types of solar energy systems which utilize conventional flat-plate solar collectors. The generalized  $\phi$ -curve method in its original form, however, has several drawbacks. The calculation effort required to assess long-term collector performance is significant. The calculations can not be completely automated on a computer or hand calculator because many graphs are needed for which analytical representations are not available.

In this paper, the  $\phi$ -curve method is reviewed and situations for which the method is useful are described. Then, an easier method, using daily  $\phi$ -charts, rather than the original hourly  $\phi$ -curves, is presented. The  $\phi$ -charts greatly reduce the calculations required to determine flat-plate collector utilizability.  $\phi$ -charts can be easily implemented on a programmable hand calculator. A comparison of the original hourly and the new daily calculation methods is presented. An example demonstrating the use and utility of the  $\phi$ -charts is also included.

THE PLACE OF EXTREME ASYMMETRICAL NON-FOCUSSING CONCENTRATORS IN SOLAR ENERGY UTILIZATION, by D. R. Mills.  
Solar Energy, vol. 21, no. 5, 1978, p. 431-434.

The physical form of an ideal trough concentrator is very closely (but not invariably) related to the orientation of its acceptance angle with respect to its entrance aperture. The "tilt" of the acceptance angle rigidly affects the performance of the concentrator and can be used to quantify a property which will be called the "symmetry" of the device. This paper will show that asymmetrical non-focussing ideal concentrators—in particular, the extreme asymmetrical forms—are often to be preferred to symmetrical concentrators such as the CPC in solar applications.

OPTIMAL DISTRIBUTION OF HEAT CONDUCTING MATERIAL IN THE FINNED PIPE SOLAR ENERGY COLLECTOR, by M. Kovarik.  
Solar Energy, vol. 21, no. 6, 1978, p. 477-484.

Economic analysis has been applied in the past to some problems in the design and operation of solar energy collectors[1-3]. The value of some such studies tends to be eroded by subsequent changes of cost levels and production techniques. The present article attempts a revision of some earlier work, with emphasis on generalisation of the results. The intention is to reduce those parameters of the design process which are influenced by the changing cost conditions to the smallest possible number. It has been found that only two cost parameters are relevant to the main design problem set in the following form: What are the dimensions and profile of a finned tube solar energy collector which, subject to conventional assumptions and some constraints, produces maximum quantity of heat per unit investment.

The above problem will be solved for the case of linear heat transfer within the collector structure with and without the additional constraint of uniform fin thickness. A particularly simple equation for the fin cross-section area will be obtained and the main results presented in graph form.

COMPARISON OF TRANSIENT HEAT TRANSFER MODELS FOR FLAT PLATE COLLECTORS, by N. E. Wijeysundera.  
Solar Energy, vol. 21, no. 6, 1978, p. 517-521.

In the present study we have compared the approximate model of Klein *et al.*[1], with the exact method of analysis given in Ref. [3] for air heater systems. On the basis of this comparison we have introduced a modified approximation which gives better agreement with the results of the exact calculation for flat plate air heaters with two and three covers. The importance of the thermal capacitance of such collectors in the prediction of the long term behaviour is also considered in the present study.

**A79-42895** A reflecting radiation trap for producing higher temperatures in flat-plate solar collectors. J. H. Morehouse (Texas A & M University, College Station, Tex.) and R. I. Vachon (Auburn University, Auburn, Ala.). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers, Volume 2, (A79-42886 18-34) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 135-140, 10 refs.

The paper presents analyses of a proposed reflecting radiation trap as a mechanical means to decrease the effective emissivity of a flat-plate solar collector. The proposed trap involves the incorporation of rectangular channels with serrated walls on the sun side of the flat-plate collector. These channels effectively reduce the surface emissivity by reflecting some of the emitted radiation back onto the emitting surface. Engineering-model traps are analyzed as functions of trap configuration, wall reflectivity and emissivity, insolation, conduction-convection losses, and equilibrium temperatures. The effective absorptivity of the collector is increased, while effective emissivity is decreased. The results indicate that although the trap increases the operating temperatures of flat-plate collectors for a given set of insolation and environmental conditions, the optimum use of the trapping concept is expected to be in conjunction with sun-tracking collectors. S.D.

#### ECONOMETRIC ANALYSIS OF CONCENTRATORS FOR SOLAR CELLS,

by Aharon S. Roy.

Solar Energy, vol. 21, no. 5, 1978, p.371-375.

**Abstract**—When concentrating collectors are used with photovoltaic solar cells, the cost of the generated electricity is controlled by the concentrator cost. This enables the use of highly efficient cells and collectors of high concentration ratios, thereby reducing both the cell and the non-cell cost components per unit generated electricity. Cost analyses indicate the significance of distinguishing between the cell-cost and the non-cell cost-components.

**N78-24813\*** Wyle Labs., Inc., Huntsville, Ala. Solar Energy Systems Div.

#### INDOOR TEST FOR THERMAL PERFORMANCE EVALUATION ON THE SUNWORKS (AIR) SOLAR COLLECTOR

Jan. 1978 34 p refs Prepared for DOE

(Contract NAS8-32036)

(NASA-CR-150666; WYLE-TR-531-17)

Avail: NTIS

HC A03/MF A01 CSCL 10A

The test procedure used and the results obtained from an evaluation test program conducted to obtain thermal performance data on a Sunworks single glazed air solar collector under simulated conditions are described. A time constant test and incident angle modifier test were conducted to determine the transient effect and the incident angle effect on the collector. These results and the results of the collector load test are also discussed.

Author

#### HEAT MIRRORED SOLAR ENERGY RECEIVERS

Phillip O. Jarvin

J. of Energy, vol. 2, no. 2, March-April 1978, p95-99

A simplified model of a heat mirrored cavity receiver is considered herein and used to predict cavity operating efficiency as a function of incident sun level, cavity operating temperature, and heat mirror reflectance edge position. The results are compared with those for a windowed receiver where escape of reradiated energy is prevented by a process of radiation absorption in the window, rather than by reflection back to the cavity interior as in the case of the heat mirror. Experimental data on some existing heat mirrors are summarized, and achievable performance improvements with existing heat mirror films are calculated and compared with idealized predictions.

#### THE EFFECTS OF AIR LEAKS ON SOLAR AIR COLLECTOR BEHAVIOUR.

D. J. Close & M. B. Yusoff

Solar Energy, Vol. 20, No. 6, 1978, p. 459-463.

**Abstract**—The construction of conventional solar air collectors and the fact that they will operate with a significant pressure difference between the heated air stream and ambient, suggests that significant quantities of air may leak into or out of them. A search of the literature reveals no consideration of the effects these air leaks may have on the validity of collector efficiency measurements, on the efficiency itself, or indeed what the meaning of efficiency is under such operating conditions. This paper discusses the meaning of collector efficiency when leaks into the collector occur, analyses the effects on efficiency measurements, and solves the collector efficiency for the simple case of a constant leakage rate along the collector. Assuming that air leaking in from ambient can replace deliberate fresh air supply to the load as in building heating, then significant measurement errors are made if air leaks in to the collector are not accounted for. Further, the collector efficiency is increased over the no leak case, so that complex construction methods to make the collector air tight are probably not warranted.

#### THE APPLICATION OF THERMOGRAPHY TO LARGE ARRAYS OF SOLAR ENERGY COLLECTORS, by Robert G. Mansfield and Anthony Eden.

Solar Energy, vol. 21, no. 6, 1978, p.533-537.

Thermography may be effectively used to produce a more efficient solar energy collection system through its display of otherwise undetected problem areas. Liquid solar collectors can experience many difficulties associated with their performance. One of these concerns the maintenance of uniform flow throughout an array. Flow imbalances can exist within individual collectors and can reduce the overall efficiency of thermal collection; therefore, detection of these imbalances becomes important. One possible detection method is thermography. This report deals with thermography and its special application to solar energy research at the United States Air Force Academy[1]. Topics covered include the prediction and observation of flow problems within a large solar collector array, as well as the results of actions taken to alleviate them through the use of thermography.

# CONCENTRATION OF THE SUN'S RAYS USING CATENARY CURVES.

G. A. Rottigni

Applied Optics, Vol. 17, No. 6, March 1978,

p. 969-974

The purpose of the present work is to show that it is possible to concentrate the sun's rays using reflecting surfaces the curvature of which, produced by gravity, is described by a catenary equation. As we know from optics, a parabolic curve concentrates rays parallel to its axis in one point giving zero dispersion. If however the rays are not parallel to the axis of the parabola, the concentration gives a dispersion that increases as the angle grows between the axis of the parabola and the incident rays. This fact creates a serious problem concerning the construction of sun-ray concentrators of the circular-parabolic and the parabolic-cylindrical type, because, due to the movement of the sun, it is necessary to reset the concentrator continuously.

# OPTIMAL SIZING OF SOLAR COLLECTORS BY THE METHOD OF RELATIVE AREAS, by C. Dennis Barley and C.

Byron Winn.

Solar Energy, vol. 21, no. 4, 1978, p.279-289.

A method is presented for calculating directly, without iteration, the approximate collector area which minimizes the total life-cycle cost of an active solar space and/or domestic hot water heating system. The method is based on an empirical relationship between annual solar load fraction and relative collector area. This relationship was determined by correlating data that were generated by the Klein, Beckman and Duffie F-Chart program, which in turn is based on a correlation of digital computer simulation results. The calculations may be performed in a few minutes using a hand-held calculator. Required data are tabulated for 170 locations, and a solved example is included. Compared to results from the F-chart program, deviations of total life-cycle costs from the minima are typically less than 3 per cent. Uncertainty of future energy prices is regarded as the limiting factor in the accuracy of the optimization calculations. A detailed economic analysis is included. (Author)

# RADIATIVE COOLING OF TiO<sub>2</sub> WHITE PAINT

A.W. Harrison and M.R. Walton

Solar Ener., v.20, no.2, 1978, p.185-188.

Selective surfaces have been used extensively in solar energy collectors[1], but to date have not been exploited to any great extent in radiation cooling devices in which advantage is taken of the atmospheric window region 8-13  $\mu\text{m}$ . As noted by Johnson[2] both natural and man-made structures are known to cool below ambient temperature under certain environmental conditions. In a recent experimental study Catalanotti *et al.*[3] have shown that substantial cooling of a selective surface below ambient temperature can be achieved provided certain conditions are satisfied. The work reported here is similar to that of Catalanotti *et al.* but has been carried out under different environmental conditions and with a different selective surface. The underlying theory has been given in the earlier study[3] and shows that the power radiated from a selective surface of spectral emissivity  $\epsilon(\lambda)$  and which obeys Lambert's cosine law is

# DUCT AND PIPE LOSSES IN SOLAR ENERGY SYSTEMS, by

W. A. Beckman.

Solar Energy, vol. 21, no. 6, 1978, p.531-532.

The energy lost from ducts and pipes leading to and returning from the collector in a solar energy system can be significant. This note presents a method for evaluating the influence of these losses on the overall system performance. It is shown that the combination of ducts plus solar collector is equivalent in thermal performance to another solar collector with different values of  $U_f$  and  $(\tau\alpha)$

A78-19829\* Irradiance for skew rays incident upon a trough-like solar collector of arbitrary shape. G. L. Strobel and D. G. Burkhard (Georgia, University, Athens, Ga.). *Solar Energy*, vol. 20, no. 1, 1978, p. 25-27. NASA supported research.

A78-19835 Geometric factors for plane specular reflectors. N. E. Wijesuniera (University of Sri Lanka, Peradeniya, Sri Lanka). *Solar Energy*, vol. 20, no. 1, 1978, p. 81-85. 7 refs.

The solar radiation collection of flat plate collectors, hot-box ovens, and thin film solar cells may be increased by plane specular reflectors. A general formula is derived for calculating the geometric factor between the plane specular reflector and the corresponding collector surface. It is based on matrix transformations, and is therefore applicable to digital computer programs. Specific geometric factors for east-west and north-south configurations are also discussed. S.C.S.

A TEST FOR DETERMINING A BEST FLOW RATE THROUGH SOLAR COLLECTORS, by H. C. Hewitt Jr., B. K.

Parekh and G. L. Askew.

Journal of Energy, vol. 2, no. 6, Nov.-Dec. 1978, p. 342-345.

This paper gives the testing apparatus, instrumentation, and testing procedure which can be used to determine a design flow rate through the manifold for any particular system of identical flat-plate solar collectors. The use of two identical collectors in a side-by-side arrangement is employed. A least-squares mathematical model is developed to fit the data to the commonly accepted collector performance equation,  $F_R = [CG/U_L] [1 - \exp(-F' U_L/GC)]$ . A variation of this model is solved by trial-and-error on a computer. Pressure drop data are correlated by a least-squares parabola curve, and an economic model is developed to find the optimum flow rate for the particular type of collector.

A78-19837 Inexpensive solar collectors for agricultural requirements. J. H. Schlag, D. C. Ray, A. P. Sheppard, and J. M. Wood (Georgia Institute of Technology, Atlanta, Ga.). *Solar Energy*, vol. 20, no. 1, 1978, p. 89-91. Research sponsored by Georgia Institute of Genetics; U.S. Department of Agriculture Contract No. 12-14-7001-566.

Two types of inexpensive solar collectors are discussed: the black film, hot air collector system, and the rock absorption and storage collector system. A review is presented of collector instrumentation, noting (1) the automated data collection system used for assessing collector design research, (2) the remote data collection system for field collector evaluation, and (3) the solar instrumentation component design.

S.C.S.

SOLAR AND INFRARED RADIATION PROPERTIES OF PARALLEL-PLATE HONEYCOMB, by J.R. Felland and D.K. Edwards

Journal of Energy, vol. 2, no. 5, September 1978, p. 309-317

Three radiative transfer problems are solved for describing the thermal performance of parallel-plate honeycomb arrays used to construct solar-transparent insulated walls. First, solar transmittance is treated with scattering and polarization. Second, effective emittance (or passage transmittance) is derived for partially transparent wall materials. Third, the influence on the effective emittance of the re-radiated energy contributed by the absorbed solar radiation is determined. Results are calculated for thin-walled glass and mylar honeycombs. With the results, the engineer or architect can evaluate the merit of applying honeycombs to solar collectors, greenhouses, residences, and commercial buildings.

FLAT - SIDED RECTILINEAR TROUGH AS A SOLAR CONCENTRATOR: AN ANALYTICAL STUDY.

Donald G. Burkhard, George L. Strobel, & Daryl R. Burkhard

Applied Optics, Vol. 17, No. 12, June 1978, p. 1870-1883

FILON PANELS: A TECHNICAL REPORT, by James E. Whitridge.

Sunworld, vol. 2, no. 1, February 1978, p. 18-21.

All Filon panels are manufactured with acrylic-fortified polyester resin reinforced with fiberglass, and all contain ultraviolet (UV) light absorbers to reduce color degradation; but it is generally agreed that Tedlar®-clad Filon panels with a weather-protective surface of DuPont's polyvinyl fluoride

film are best suited for use in solar applications. The Tedlar surface provides additional UV protection as well as protection from surface degradation, and its matte finish tends to reduce reflectivity. The film is virtually impervious to erosive and corrosive atmospheres.

A79-33217 # System data on flat-plate collectors and its optimization. H. P. Garg (Central Arid Zone Research Institute, Jodhpur, India). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings, Volume A. (A79-33212 13-44) Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 65-86. 45 refs.

Design parameters are discussed for solar energy flat-plate collectors employed for such applications as water heating, space heating, air conditioning and crop drying. Among the parameters studied for optimization are the air gap between the collector and the first glazing, coating types, and collector tilt. In addition, the effect of dirt on the transmittance of the collector plate, the interconnection of absorbers, and collector-booster systems are considered.

J.M.B.



**A79-31447** The honeycomb heat trap - Its application in flat plate solar collectors. D. Hart (Watershed Energy Systems, Ltd., Toronto, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 2. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 10 p.

It is pointed-out that a collector operating under Canadian midwinter conditions loses the major portion of its energy back through the covers and sides to the outside air. The primary mechanisms for this heat loss are examined along with the approaches used to reduce the effectiveness of these mechanisms. It is found that very few collector designs incorporate any means for suppressing free convection, which is the major source of heat loss. One such collector is the evacuated-type collector. A description is presented of another approach involving the use of honeycomb cells to suppress convection. It was found that by partitioning the air layer between the hot and cold surfaces, convective motion could be virtually eliminated. In a comparison of the performance of various solar collectors it was found that honeycomb panels provided 61.7%

of the annual heating load for a house, while air collectors of the same area supplied only 44.2% of the load. G.R.

**A79-31408** Thermal performance evaluation of a flat-plate cylindrical parabolic concentrator and a flat-plate collector. P. Singh and K. F. Schenk (Ottawa, University, Ottawa, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 13 p. 6 refs. Research supported by the National Research Council of Canada.

An investigation is conducted regarding the design, building, and testing of a flat-absorber cylindrical parabolic concentrator (CPC) and a conventional type of flat-plate collector. Experimental studies showed that the flat-absorber CPC is more cost-effective than the conventional flat-plate collector, if operated at solar noon under the specified conditions. Although the flat-absorber CPC utilizes much less absorber plate area, the total cost per unit area for both the collectors balances out because of the additional cost of the reflecting surface. However, it is expected that the cost of labor in building the parabolic surface would be reduced marginally by mass production. Another important consideration is that since the absorber width is large enough to receive even the off-axis incident rays, no tracking mechanism is needed. The collector can also be operated on cloudy or hazy days. G.R.

**A79-31451** Studies on solar collector performance at NRC. S. J. Harrison and J. R. Sasaki (National Research Council, Div. of Building Research, Ottawa, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 2. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 12 p. 8 refs.

As part of NRC's responsibility for the development of solar heating standards and test methods, a facility has been established at the Division of Building Research (DBR) to obtain data on the thermal performance and durability of solar collectors. A variety of solar collectors are being tested to determine the factors that affect their performance and life. A review of testing procedures is underway to assess their suitability for use in Canada. This paper describes the solar calorimeter apparatus and the in-house activities currently being pursued at DBR. (Author)

**A79-45216** Graphical representation of solar collector performance. H. G. Paul (Alabama, University, Huntsville, Ala.). In: Application of solar energy; Proceedings of the Third Southeastern Conference, Huntsville, Ala., April 17-19, 1978. (A79-45201 19-44) Huntsville, Ala., UAH Press, 1978, p. 233-240. 7 refs.

Determination of the thermal performance of solar collector modules by test according to ASHRAE Standard 93-77 involves a number of variables, such as incident solar radiation, ambient temperature, fluid inlet and exit temperatures and mass flow across the collector. A diagram arrangement is presented which elucidates the roles of these variables as to efficiency and useful energy output of the collector over an ample operational range. A blank quadrant is provided which allows incorporation of the straight-line or other thermal efficiency curve of collectors for comparison, extrapolation or analysis. The graphical method presented should greatly facilitate the interpretation of the ASHRAE Standard 93-77 recommended Hottel-Whillier-Bliss plot of the measured thermal performance of solar energy collector modules. (Author)

**A79-31406** Dimensional relations for free convective heat transfer in flat-plate collectors. K. G. T. Hollands (Waterloo, University, Waterloo, Ontario, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 12 p. 11 refs. Research supported by the U.S. Department of Energy.

Free convection heat transfer is one of the dominant modes of heat loss in a flat plate solar collector. Recently there have been reported new data and correlation equations for free convective heat transfer in various geometries similar to those found in solar collectors. In most of this work, the results have been reported in terms of dimensionless groups. This method of presentation does not immediately indicate how the results may be used for design decisions on collectors. A description is presented of the new results in terms of dimensional equations and graphs, thereby pointing the way to improved design techniques. Particular emphasis is placed on the new free convective information resulting from studies carried out at the University of Waterloo. G.R.

**A79-43018** An overview of intermediate temperature solar collector and energy storage technology. F. Kreith, J. N. Castle, and C. E. Wyman (Solar Energy Research Institute, Golden, Colo.). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 6. (A79-43012 18-34) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 255-268. 47 refs.

This paper presents a survey of concentrating solar collector and energy storage technology suitable for the mid-temperature range between 370 and 670 K. The thermal performance of generic types of concentrating collectors are compared and the various methods for providing energy storage in the temperature ranges achievable with these collectors are summarized. The objective of this review is to compile the information necessary for the design of solar energy systems in the mid-temperature range and to indicate areas that require additional research to make solar energy economically viable for industrial heat applications. (Author)

**A79-31405** Energy analysis of an aluminum solar collector. W. Ashton and J. E. Robinson (Waterloo, University, Waterloo, Ontario, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 9 p. 20 refs.

An analysis was conducted of the energy consumption involved in an installation of aluminum solar collectors to ascertain the length of time which would be required to recover the energy invested in manufacture. It was found that approximately four years of operation will be required to regain the energy consumed in the manufacture of the solar collector system from raw materials. It was also found that the use of recycled metal substantially reduces the energy pay-back period to just over one year. In this case, then, the energy viability of one new technology, a solar collector system, is enhanced significantly by parallel developments in others such as metal recycling. G.R.

PERFORMANCE TESTING OF SOLAR COLLECTORS, by B. Justin.  
Sunworld, vol. 2, no. 3, August 1978, p.66-71.

*Agreement on test  
procedures is the  
first step.*



A79-31413

A solar collector thermal performance test for developmental programs. E. C. Shewen and K. G. T. Hollands (Waterloo, University, Waterloo, Ontario, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 13 p. 8 refs. Department of Supply and Services Contract No. 12SO-31155-7-4409.

An alternative thermal test procedure for solar collectors to that described in ASHRAE Standard 93-77 is described. Particularly suited to in-house developmental programs, the method permits a substantial reduction in the time required for test completion, while yielding an accuracy that should be comparable, for a given type of design. Considerable use is made of indoor heat loss testing and only one outdoor test is required. In this paper the method is outlined and a procedure for correcting the results to standard ambient conditions is described. A description of a test apparatus for air-heating collectors, built at the University of Waterloo is given and some experience in design of mixers and thermocouple collars is reported.

A79-31423

The performance of a site built, air heating, vertical collector with snow reflector in Quebec. R. G. Kerr and M. M. Shapiro (Concordia University, Montreal, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 12 p. 10 refs.

A screen-type vertical air heating collector with double glazing was installed in 1975 as the south wall of a house near La Macaza, Quebec, 170 km north of Montreal. The collector was built on site, using normal construction materials, for a gross cost of \$70/sq m, and a net cost of \$45/sq m, in 1975 dollars. The house and solar heater were monitored during the 1976-77 heating season. The noon efficiency curve of the collector compares favourably both with that of an experimental and with that of a factory-built collector. The monthly average efficiencies ranged from 32% in March to 42% in October. The ratio of solar heat to the sum of solar and baseboard heat supplied ranged from 0.29 in November to 0.76 in March, and was 0.5 over the entire heating season. Daily and monthly solar radiation and solar heat collected, plus monthly average efficiencies and solar fraction are presented. (Author)

33028 (DOE/NASA/CR-150860) Qualification test and analysis report: solar collectors. (Owens-Illinois, Inc., Toledo, OH (USA). Solar Energy Products Group). Dec 1978. Contract EX-76-A-29-1037. 148p. Dep. NTIS, PC A07/MF A01.

Test results show that the Owens-Illinois Sunpak/sup TM/ Model SEC 601 air-cooled collector meets the national standards and codes as defined in the Subsystem Performance Specification and Verification Plan of NASA/MSFC Contract NAS8-32259, dated October 28, 1976. The architectural and engineering firm of Smith, Hinchman and Grylls, Detroit, Michigan, acted in the capacity of the independent certification agency. The program calls for the development, fabrication, qualification and delivery of an air-liquid solar collector for solar heating, combined heating and cooling, and/or hot water systems.

## SHADING AND SPACING IN PARABOLOIDAL COLLECTOR ARRAYS, by E. P. Edwards.

Solar Energy, vol. 21, no. 5, 1978, p.435-439.

This paper evaluates the variations in losses due to shading as a function of spacing for square arrays. It is not realistic to increase the spacing between collectors sufficiently to completely eliminate shading caused by adjacent collectors, as several costs increase with increased spacing. These costs are dependent upon the links between the mirrors and the central control/power plant, which in turn depend upon the system used to control the mirrors, and the system used to collect the energy from the mirrors. In this paper the work of Williams[1] on energy transfer costs is used in conjunction with the shading calculations to evaluate the optimum spacing for collector arrays. In addition the minor costs of the links for both communication and supplying power to the collectors for movement are considered.

## HOMEMADE SOLAR ENERGY COLLECTOR, by Dean Kramer. Sunworld, vol. 2, no. 1, February 1978, p.22-24.

Three years ago I constructed an experimental solar collector at my home to test the feasibility of solar house heating. In searching the solar energy literature in preparation for the project, I found general agreement that about one square foot of collector is needed for each two square feet of living area for optimum solar heating. Optimum is about 80% and is synonymous with cost-effectiveness because overdesign has severe cost penalties.

A78-19827

Solar energy collector orientation and tracking mode. R. C. Neville (California, University, Santa Barbara, Calif.). Solar Energy, vol. 20, no. 1, 1978, p. 7-11, 7 refs.

The maximum solar energy available to an earth-surface collector is examined as a function of latitude, the north-south tilt of the collector from the earth's surface, and whether the collector is an ideal tracker (follows the sun both north-south and east-west), an east-west tracker (follows the sun east-west but is fixed in the north-south direction) or a fixed type. It is shown that the ideal tracker gives maximum potentially available energy, the use of an east-west tracking device results in 5-10 per cent degradation in potential performance, of fixed collectors is degraded by close to 50 percent. Insolation data by season of the year is also provided.

(Author)

**A78-19828** Design and performance of an air collector for industrial crop dehydration. P. W. Niles, E. J. Carnegie, J. G. Pohl, and J. M. Cherne (California Polytechnic State University, San Luis Obispo; TRW, Inc., Systems and Energy Div., Redondo Beach, Calif.). *Solar Energy*, vol. 20, no. 1, 1978, p. 19-23. 7 refs. NSF Grant No. ERT-74-19063.

Test results are reported for the operation of unglazed and single-glazed solar collectors used to heat air to the 90 C (194 F) range. The collectors were constructed of standard black-painted metal decking and were tested in various lengths so that pressure drops and convective heat transfer rates could be varied independent of collector operation temperature. It is shown that the experimental collector performance results with single pass operation are in substantial agreement with standard collector analysis procedures. These results give a firm basis for collector and system optimization. (Author)

**A78-19830** The effect of off-south orientation on the performance of flat-plate solar collectors. J. D. Felske (MIT, Cambridge, Mass.). *Solar Energy*, vol. 20, no. 1, 1978, p. 29-36. 9 refs. NSF Grant No. PTP-75-05156.

There are many instances in which an off-south installation of a flat-plate solar collector is more compatible with a building's orientation than a due-south installation. In these cases it is important to determine the magnitude of the performance sacrificed by conforming to the building architecture. The study investigates the collector performance and optimum tilt as functions of the off-south angle, collection temperature, number of glass covers and the relative amounts of direct and diffuse radiation. It was found that the yearly energy collection for a given collector tilt is insensitive to the off-south angle and that in some cases it actually improves with increasing azimuthal angle. It was also found that for a given azimuthal angle an optimum collector tilt exists which is between 3 and 10 less than the latitude. Calculations were based on New York City weather. (Author)

**N78-33610/** National Technical Information Service, Springfield, Va.

**FLAT PLATE SOLAR COLLECTOR DESIGN AND PERFORMANCE. CITATIONS FROM THE ENGINEERING INDEX DATA BASE Progress Report, 1970 - Jun. 1978**  
Audrey S. Hundemann Aug. 1978 150 p  
(NTIS/PS-78/0841/3) Avail: NTIS HC \$28.00/MF \$28.00  
CSCL 10A

Citations from worldwide literature on the design, thermal performance, and optimization of air- and liquid-type flat plate collectors are covered. Topic areas include heat loss and heat transfer, effect of orientation, corrosion protection, optical coatings, enhancement of performance through the use of planar reflectors, and the effect of honeycomb layers on collector performance. Grooved corrugated, or V-trough collectors are studied. Abstracts dealing with methods of measuring the performance of flat plate collectors and computer optimization studies are included. (This bibliography contains 144 abstracts.) GRA

**CONTROLS: REDUCING SOLAR COLLECTOR AREA BY 35% TO 40%.**

Alwin B. Newton

*Ashrae Journal*, vol. 20, no. 9, September 1978, p. 45-47

**N80 10813/** Battelle Pacific Northwest Labs., Richland, Wash.  
**SUMMARY REPORT OF THE SOLAR REFLECTIVE MATERIALS TECHNOLOGY WORKSHOP**  
M A Lind and L E Ault Oct 1978 93 p Workshop held at Denver, 28-30 Mar 1978  
(Contract EY 76-C-06 1830)

(PNL-2763; Conf-780380) Avail: NTIS HC A05/MF A01

Solar reflector materials technology was assessed. Metals, metallic films and alloys, and dielectric or ceramic stacks were considered as reflecting surface materials. Protective coatings discussed included polymer paints and films, inorganic coatings, and thin glass. The mirror support structures considered were polymer foams, cellular glass, aluminum honeycomb, wood, and fiberglass and epoxy composites. The requirements and properties for reflector materials were discussed along with environmental tests and actual field experiences with solar collector structures. High concentration ratio and central receiver concepts were emphasized. K L

**THE PHOTOCHEMICAL HEAT PIPE**, by Bo Carlsson and Gunnar Wettermark

*Solar Energy*, vol. 21, no. 2, 1978, p. 87-92

**Abstract**—The performance of a solar collector system for high temperature heat delivery based on a photochromic reaction is discussed. The system consists of a non-focusing collector and a reactor integrated into a flow system. In the collector, kept close to ambient temperature, the chemical potential of the photochromic system is increased through an endothermic photochemical reaction and is used to drive the reverse thermal reaction taking place in the reactor at a high temperature. No separation of the photoproducts is involved. Accordingly, the highest temperature at which heat can be delivered from the reactor is determined by the maximum attainable photostationary state in the collector and not, as in a conventional flat-plate collector, by heat-loss from the collector to the surroundings. Accordingly, the highest temperature at which heat can be delivered from the reactor is determined by the maximum attainable photostationary state in the collector and not, as in a conventional flat-plate collector, by heat-loss from the collector to the surroundings. The functioning of the device is exemplified by calculations for a model system utilizing the photodissociation of gaseous nitrosylchloride. The results show that it should be possible to build a system which, on a clear day, delivers about 100 W heat at temperature above 200°C for each m<sup>2</sup> collector area. A tenfold reduction in the radiation flux density of the incident light will only slightly reduce output efficiency.

**IDEAL PRISM SOLAR CONCENTRATORS**, by D. R. Mills and J. E. Giutronich.

Solar Energy, vol. 21, no. 5, 1978, p.423-430.

**Abstract**—Non-imaging solar concentrators using both symmetrical[1-3] and asymmetrical mirrors have recently been described by several workers[4-6]. In this paper, a completely separate but parallel family of non-imaging concentrators is proposed which utilizes the phenomenon of Total Internal Reflection within a material of high refractive index to achieve concentration. In both symmetrical and asymmetrical forms, the new concentrators satisfy the maximum concentration limits for ideal radiation transformers for a given acceptance angle[7]. Light radiating from the exit aperture is restricted in angle, but concentration performance is very good and irradiation of the exit aperture is much more uniform for a distant point source than in any other design. The new forms are easier to construct than CPC concentrators filled with refractive medium because, in most designs, only flat surfaces are required and far less refractive material is used for a given aperture. Stationary concentrators with acceptance angles up to that of a flat plate are possible.

**N78-30784/ Sandia Labs., Albuquerque, N. Mex.  
LINEAR CONCENTRATING SOLAR COLLECTORS: CURRENT TECHNOLOGY AND APPLICATIONS**

James A. Leonard Jul. 1978 38 p refs

(Contract EY-78-C-04-0789)

(SAND-78-0949) Avail: NTIS HC A03/MF A01

Linear concentrating collector technology is reviewed. Included are fundamentals of the technology; descriptions of collectors with particular emphasis on the types tested at the DOE/Sandia Midtemperature Solar Systems Test Facility (MSSTF); performance test results; problems identified through operating experience; cost projections; and a discussion of applications of linear concentrating and midtemperature solar collectors. DOE

**A79-31402 Ranking and evaluation of flat-plate collectors**  
- Two new approaches. J. H. White (Dilworth, Secord, Meagher and Associates, Ltd., Toronto, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 12 p.

An index format is developed which will allow ready ranking of a collector's ability to deliver heat to a seasonal-storage system. It is location sensitive but not configuration sensitive. There are indications that the index could also be applicable to short storage systems and be developed further into a system design tool. When used in conjunction with a reference system which presents the optimum efficiency in terms of a number of 'equivalent reflections' and an 'equivalent resistance' concept, it is possible to see that single-glazed collectors, to date, are quite restricted in their ability to deliver heat, while some antireflective double-glazed collectors with selective coatings have established double the index margins and therefore almost double the heat delivering capability when used in seasonal-storage systems. G.R.

**A79-31403**

**Optimization of the flow passage geometry for air heating solar collectors.** E. C. Shewen and K. G. T. Hollands (Waterloo, University, Waterloo, Ontario, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 12 p. 9 refs. Department of Supply and Services Contract No. 12SQ-31155-7-4409.

The flow passage geometry for air heating solar collectors of the underflow type has been examined from the point of view of maximizing the collector efficiency for a specific pressure drop. Parameters studied include the absorber to air stream heat transfer coefficient, the flow passage dimensions, the pressure drop and the air flow rate. A generalized study of improving the heat transfer coefficient for a specified pressure drop is presented. This study has led to a novel air heater design referred to as the 'short path concept'. (Author)

**A79-31404**

**Performance analysis of a flat-plate solar collector using 'forge-fin' tubes.** K. F. Schenk, C. R. Dua, and J. T. Munoz (Ottawa, University, Ottawa, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 14 p. 9 refs. Research supported by the National Research Council of Canada.

An analysis is conducted of a flat-plate solar collector utilizing internally finned tubes to obtain its thermal performance. These 'forge-fin' tubes enhance the heat transfer between fluid and absorbing plate. A solar test facility was built and the collector efficiency obtained. It was found that the efficiency of the proposed collector using internally finned tubes is about 10% higher than that of a conventional type of flat-plate collector under similar outdoor conditions. It had been pointed out by Watkinson et al. (1974) that 2 feet of 'forge-fin' tube was equivalent to 8 feet of smooth tube in heat exchangers due to its augmented heat transfer properties. After evaluation of the performance of the proposed flat-plate solar collector using these tubes, an improvement has been noticed over that of a collector using smooth tubes. However, 'forge-fin' tubes are more expensive than conventional smooth tubes and this increases the cost per unit area of the proposed collector. G.R.

**N78-33689/ National Technical Information Service, Springfield, Va.**

**SOLAR ENERGY CONCENTRATOR DESIGN AND OPERATION. CITATIONS FROM THE ENGINEERING INDEX DATA BASE** Progress Report, 1970 - Jun. 1978  
Audrey S. Hundemann Aug. 1978 174 p  
(NTIS/PS-78/0839/7) Avail: NTIS HC \$28.00/MF \$28.00 CSCL 10A

Worldwide research on the design and operation of various types of solar energy concentrators is discussed. Topic areas cover thermal and optical performance of Fresnel lenses, compound parabolic concentrators, fixed mirror concentrators, and planar reflector enhancement of flat plate collector systems. A few abstracts deal with V-trough concentrators and methods to calculate performance of concentrators. A separate published search on heliostat systems is available. (This bibliography contains 167 abstracts) GRA

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**Testing of solar collectors and systems**  
: [proceedings of] conference (C11)  
at the the [sic.] Royal Institution,  
April 1977. London : International  
Solar Energy Society, UK Section,  
1977.  
[1], 82 p. : ill. ; 30 cm. £4.50  
Cover title. Includes  
bibliographical references.  
1. Solar collectors -- Testing --  
Congresses. 2. Solar houses -- Testing  
-- Congresses. I. International Solar  
Energy Society. UK Section.  
697.78 77-377410 78V44146

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**Abdelrahman, Mohamed A. M.**  
Technical evaluation of gaseous sus-  
pensions of graphite for the absorption of  
concentrated solar radiation / par  
Mohamed A. M. Abdelrahman. -- Zurich :  
Juris-Verlag, [197-]  
[iv], viii, 164 p. : ill. ; 23 cm. --  
(Communication de l'institut de thermique  
appliquée ; nr. 6)  
Bibliography: p. 159-164.  
ISBN 3- 260-04592-9  
1. Solar collectors. 2. Solar  
heating.  
I. Title. II. Series: Institut de  
thermique appliquée. Communication ;  
nr. 6.

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1976  
**Optics in solar utilization II, August 24-25,**  
1976, San Diego, California / editor:  
Clifford Selvage. -- Palos Verdes Estates,  
Calif. : Society of Photo-optical Instru-  
mentation Engineers, cl977.  
xxvi, 158 p. : ill. -- (Proceedings of  
the Society of Photo-optical Instrumenta-  
tion Engineers ; v. 85)  
Includes bibliographies.  
1. Solar energy--Congresses. 2. Solar  
radiation--Optical instruments--Congresses.  
I. Selvage, Clifford, ed. II. Society  
of Photo-optical Instrumentation Engineers.  
III. Title. IV. Series: Society of  
Photo-optical Instrumentation Engineers.  
Proceedings ; v. 85.

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1976  
**Solar Energy Seminar, University of**  
Regina and University of Saskatchewan,  
1976.  
Applications of solar energy :  
proceedings of the Solar Energy  
Seminar / editor, Peter J. Catania.  
Regina, Sask. : University of Regina,  
Canadian Plains Research Center, 1976.  
165 p. : ill. ; 23 cm. (Canadian  
plains proceedings ; 3 0317-6407)

Solar Collectors,  
Robert W. Besant, Faculty of Engineering, University  
of Saskatchewan, Saskatoon, Saskatchewan . . . . . 25

# SEASONAL SOLAR COLLECTOR PERFORMANCE WITH MAXIMUM STORAGE.

P.J. Lunde.

ASHRAE J., Nov.1977, p.55-

*An integrated form of the basic solar collector heat balance equations is derived which permits use of average temperature and radiation data to determine seasonal performance when the average storage temperature is known. For the limiting case of infinite storage and hence constant storage temperature, a typical collector performance is presented graphically for a variety of collector operating conditions.*

**A79-33988**      **New concept in solar thermal collectors.** H. J. Spitzer (U.S. Army, Mobility Equipment Research and Development Command, Fort Belvoir, Va.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1. (A79-33984 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 179-190.

Models and prototypes of black liquid solar collectors were fabricated and tested. The concept of using a black fluid sheet simultaneously as absorber and heat transfer medium resulted in a considerable performance enhancement against conventional solar collectors. The weight of a total device structure also compares favorably with conventional collectors. The greatest potential of solar thermal collectors based on the concept of the black liquid, however, lies in the possible cost reduction per unit area of collector through the utilization of modern chemical engineering techniques in plastics materials. (Author)

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**Optics applied to solar energy conversion** [seminar], August 23-24, 1977, San Diego, California / Roland Winston, A. I. Mlavsky, editors ; presented by the Society of Photo-optical Instrumentation Engineers in conjunction with the IEEE Computer Society International Optical Computing Conference 77. — Bellingham, Wash. : SPIE, c1977. viii, 95 p. : ill. ; 28 cm. — (Proceedings of the Society of Photo-optical Instrumentation Engineers ; v. 114)  
(Continued on card 2)

<b>SESSION 3. THERMAL SOLAR ENERGY UTILIZATION 1</b>	<b>21</b>
114-07 Options for Solar Thermal Conversion	22
Frank Kreith, Gerard F. Lameiro, Kenneth C. Brown, Solar Energy Research Institute	
114-08 A Vacuum Solar Thermal Collector with Optimal Concentration	35
John D. Garrison, Department of Physics, San Diego State University	
114-10 Optical Evaluation Techniques for Reflecting Solar Concentrators	43
B. L. Butler, R. B. Pettit, Sandia Laboratories	
<b>SESSION 4. THERMAL SOLAR ENERGY UTILIZATION 2</b>	<b>51</b>
114-12 Five MW Solar Thermal Test Facility Heliostat Focus and Alignment System	52
Lloyd P. Oldham, Martin Marietta Corporation	
114-13 Nonimaging Solar Concentrators	60
William W. Schertz, Argonne National Laboratory	
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Donald G. Burkhard, David L. Shealy, George L. Strobel, University of Georgia	

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**Intersociety Energy Conversion Engineering Conference, 12th, Washington, 1977.**

- 779181 — **Solar Powered Steam Generation**, D. Magnoli, M. Saddy, A. V. de Carvalho, Jr., *Centro de Tec. Promon*, Rio de Janeiro, Brazil; J. B. de Siqueira, T. Oniga, *Inst. Nacional de Tech.*, Rio de Janeiro, Brazil. .... 1127
- 779183 — **High Temperature Solar Collector with an Archimedes Concentrator**, Z. Antoniuk, H. B. Palmer, *Penn. State University*, University Park, Pa. .... 1134
- 779184 — **Development Status of the Fixed Mirror Solar Concentrator**, J. L. Russell, G. H. Eggers, J. R. Schuster, *General Atomics Co.*, San Diego, Calif. .... 1141
- 779185 — **Considerations for Using Solar Concentrators in Photovoltaic Systems**, C. E. Backus, D. L. Evans, L. W. Florschuetz, D. L. Jacobson, B. D. Wood, *Arizona State University*, Tempe, Ariz. .... 1147
- 779186 — **Solar Cell Array for Concentrated Sunlight**, G. Yekutieli, B. Haber, J. Mandelkorn, E. Kritchman, A. Brandsetter, R. Joulzary, *Weizmann Inst. of Science*, Rehovot, Israel. .... 1154
- 779187 — **Photovoltaic Applications in the National Park Service**, P. O. Jarvinen, C. R. Peatfield, *Mass. Inst. of Tech.*, Lexington, Mass.; H. Haiges, *National Park Service*, Denver, Co. ... 1159

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v.31  
pt.1-4
- Advances in instrumentation, v. 31, pts. 1-4; proceedings of ISA Conference and Exhibit, Houston, Texas, October 11-14, 1976. -- Pittsburgh : Instrument Society of America, 1976.**
- 4 v. : ill. ; 29 cm.
1. Scientific apparatus and instruments-- Congresses. 2. Engineering instruments-- Congresses. I. Instrument Society of America. II. ISA Conference and Exhibit, Houston, 1976.

FLOWMETER CALIBRATION FOR A SOLAR COLLECTOR TESTING FACILITY, H. C. Hewitt, Jr. and K. Onur ... P.N. 502.....

A79-33987 Accuracy of empirical relations for flat plate collector performance prediction. P. Caetano Lobo and P. I. E. Almeida (Paraiiba, Universidade Federal, João Pessoa, Brazil). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1. (A79-33984 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 167-178. 5 refs. Research supported by the Financiadora de Estudos e Projetos.

Comparisons of measured and predicted flat plate collector efficiency are presented as functions of collector inlet temperature at given ambient air temperature and incident solar radiation intensity. Efficiency is also plotted against the ratio between collector inlet to air temperature difference and incident solar radiation intensity on a horizontal surface. The results are used to verify the accuracy and limits to validity of the mathematical model used to describe collector performance and of the corresponding numerical solution.

(Author)

**SPECIFICATIONS AND DRAWINGS ON HOW TO BUILD YOUR OWN SOLAR HOT AIR AND HOT WATER HEAT COLLECTORS.** By Daniel I. Hadley. 1976. Daniel I. Hadley, President, Hadley Solar Energy Co., Box 1456, Wilmington, DE 19899. 13 pp., paper, \$7.

Request from thousands of do-it-yourselfers for information on how they can build their own solar heat collectors has prompted Mr. Hadley to prepare a set of drawings, specifications, instructions and materials lists to enable a person with carpentry and plumbing skills to build solar hot air or hot water heat collectors. The solar heat collectors are made of standard materials. A 4 x 8 ft unit which will heat a well insulated space six times its area, in the coldest weather, can be built for less than \$150.

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**AES Coatings for Solar Collectors**  
**Symposium, Atlanta, 1976.**  
**AES Coatings for Solar Collectors**  
**Symposium, Atlanta, GA, November 9-10,**  
**1976 : organized by Glenn McDonald /**  
**presented by Symposia Committee,**  
**American Electroplaters' Society, Inc.**  
**Winter Park, FL : The Society, 1976.**  
**138 p. : ill. ; 28 cm.**  
**Includes bibliographical references.**  
**1. Solar collectors -- Congresses.**

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**Optics applied to solar energy conversion**  
**[seminar], August 23-24, 1977, San Diego,**  
**California / Roland Winston, A. I. Mlavsky,**  
**editors ; presented by the Society of Photo-**  
**optical Instrumentation Engineers in con-**  
**junction with the IEEE Computer Society**  
**International Optical Computing Conference**  
**77. -- Bellingham, Wash. : SPIE, c1977.**  
**viii, 95 p. : ill. ; 28 cm. -- (Proceed-**  
**ings of the Society of Photo-optical In-**  
**strumentation Engineers ; v. 114)**

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**Heat transfer in solar energy systems : pre-**  
**sented at the winter annual meeting of the**  
**American Society of Mechanical Engineers,**  
**Atlanta, Georgia, November 27-December 2,**  
**1977 / sponsored by the Heat Transfer Divi-**  
**sion, ASME ; edited by J. R. Howell, T. Min.**  
**-- New York : ASME, c1977.**  
**v, 135 p. : ill. ; 28 cm.**  
**Includes bibliographical references.**  
**1. Solar energy--Congresses. 2. Heat--**

**A78-21698**      **Solar collector design.** D. K. Edwards (Califor-  
 nia, University, Los Angeles, Calif.). Research supported by the  
 National Science Foundation and Energy Research and Development  
 Administration, Philadelphia, Pa., Franklin Institute Press, 1977. 63  
 p. 153 refs. \$6.50.

Solar collector design is discussed, with attention given to air  
 heaters and low- and high-pressure water heaters, fixed and tracking  
 collectors, single- and double-glazed collectors and honeycomb  
 collectors. Antireflection coatings, the control of reradiation and  
 convection, as well as thermal insulation, are considered as means of  
 collector heat loss control. In addition, heat collection and working  
 fluid flow in solar collectors are analyzed. The effect of conduit  
 spacing and absorber plate thickness on the cost effectiveness of a  
 typical solar collector is assessed. J.M.B.

**N80-18571/** National Technical Information Service, Springfield,  
 Va.  
**HELIOSTAT SYSTEM DESIGN AND OPERATION. CITA-**  
**TIONS FROM THE ENGINEERING INDEX DATA BASE**  
**Progress Report, 1970 - Jul. 1979**  
 Audrey S. Hundemann Sep. 1979 61 p Supersedes NTIS/PS-  
 78/0842

(NTIS/PS-79/0930/2: NTIS/PS-78/0842) Avail: NTIS  
 HC \$28.00/MF \$28.00 CSCL 10A

The design and use of heliostats in solar central receiver  
 thermal power systems are discussed in abstracts from worldwide  
 literature. Topic areas include heliostat systems performance,  
 efficiency, and optimization. Emphasis of the bibliography is on  
 basic research. (This updated bibliography contains 55 abstracts,  
 17 of which are new entries to the previous edition.) GRA

**N79-32703/** Sandia Labs., Albuquerque, N. Mex.  
**HELIOSTAT BEAM CHARACTERIZATION SYSTEM**  
 E. Don Thalhammer and Gary S. Phipps 1979 37 p. refs  
 Presented at the 25th ISA Intern. Instr. Symp., Anaheim, Calif.,  
 7 May 1979  
 (Contract EY-76-C-04-0789)  
 (SAND-79-0697C: Conf-790505-10) Avail: NTIS  
 HC A03/MF A01

The beam characterization system utilizes video radiometer  
 techniques to quantitatively describe the solar energy projected  
 by a heliostat. This system is designed to evaluate prototype  
 heliostats and to improve the performance of the Central Receiver  
 Test Facility heliostats. The system consists of a beam target,  
 video camera, analog image analyzer, calibration system, video  
 digitizer and a minicomputer system. The calibration technique  
 corrects for background illumination, target irregularities, vidicon  
 shading and camera dark currents. A computer code corrects  
 for off-axis camera angle and converts calibration and beam  
 data into a map of screen irradiance. DOE

**N80-16531/** Sandia Labs., Albuquerque, N. Mex.  
**HELIOSTAT BEAM CHARACTERIZATION SYSTEM. CALIBRATION TECHNIQUE**  
 G. S. Phipps 1979 23 p refs Presented at the ISA Natl Conf., Chicago, 22 Oct. 1979  
 (Contract EY-76-C-04-0789)  
 (SAND-79-1532C, CONF-791005-2) Avail NTIS HC A02/MF A01

The beam characterization system which digitizes the output signal from a standard 525 line video camera to obtain raw data for measurements of solar heliostat images is described. Absolute irradiance values are obtained from a calibrated pyrheliometer included on the target screen. A video camera measures the relative irradiance values of areas of identical spectral composition. Measurements are made over a two dimensional spatial array of N screen locations. Calibration corrections are applied to the data from the N locations to obtain a single calibrated irradiance data matrix. Methods of obtaining these corrections are discussed and measured results are presented to support the various assumptions. DOE

**N80-13642/** Sandia Labs., Albuquerque, N. Mex.  
**SOLAR THERMAL TEST FACILITY HELIOSTAT DEVELOPMENT**  
 D. E. Arvizu Jun. 1979 57 p refs Presented at Intern. Symp. on Concentrating Solar Collector Technol., Albuquerque, N. Mex., 14 Jun. 1978  
 (Contract EY-76-C-04-0789)  
 (SAND-78-1177; CONF-7806153-1) Avail. NTIS HC A04/MF A01

The STTF heliostat system is described, and performance data are discussed. The STTF, which uses an array of 222 heliostats in a north field configuration, is capable of supplying 5 MWth energy onto a target on the tower. DOE

**A79-44151** Accuracy and energy characteristics of paraboloidal heliostat system. R. A. Zakhidov and A. A. Vainer (Akademiia Nauk Uzbekskoi SSR, Tsentral'noe Proektiro-Konstruktorskoe i Tekhnologicheskoe Biuro Nauchnogo Priborostroeniia, Uzbek SSR). (Geliotekhnika, no. 5, 1978, p. 41-44.) Applied Solar Energy, vol. 14, no. 5, 1978, p. 30-32. Translation.

A general theory developed by Zakhidov et al. (1977) for multimirror concentrating systems is used to analyze a paraboloidal heliostat system. Consideration is given to both aperture/dimensional design and accuracy/energy design. B.J.

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# Institute of Electrical and Electronics Engineers, Region 5.

Energy '79... (1979).

(Card 2)

## A Status Report on the Solar Thermal Test Facility B. W. Marshall, Sandia Laboratories

The world's largest solar experimental facility is rapidly nearing operational status at Sandia Laboratories in Albuquerque, NM. Construction of the facility is expected to be completed by late spring 1978 and solar receiver tests will be initiated shortly thereafter. The facility, funded by the Department of Energy (DOE) and designated as the Solar Thermal Test Facility (STTF), is made up of a field of mirror assemblies (heliostats) which concentrate sunlight onto experiments located on a central tower. The facility is designed to deliver up to 5MW of thermal power to experimental equipment and successful operation at partial power of approximately 1.8MW was achieved in May 1977. The STTF will serve as the DOE's primary facility to test components required in solar thermal-to-electric power plants and will also serve researchers from other government agencies, research institutes, universities, and industry as a major research and development center for materials and process work which requires high solar flux conditions.

**N80-10612/** System Development Corp., Santa Monica, Calif.  
**THE 10MW(e) SOLAR THERMAL CENTRAL RECEIVER PILOT PLANT: HELIOSTAT FOUNDATION AND INTERFACE STRUCTURE INVESTIGATION**  
 R. K. Shogren and J. T. Phillips 28 Aug. 1978 87 p refs  
 Sponsored by Sandia Labs  
 (Contract EY-76-C-04-0789)  
 (SAND-78-8180) Avail NTIS HC A05/MF A01

Foundation design requirements for heliostats for the 10 MWe Solar Thermal Power Plant (STPP) were investigated. Soils data were reviewed and a soils investigation specification and recommendations were prepared as required. Foundation to collector interface requirements were studied. Candidate foundation designs were prepared with associated cost studies. Grading requirements recommendations consistent with technical and budgetary restrictions, and recommendations for construction and test of prototype foundations were developed. DOE



**N80-12610/** Brookhaven National Lab., Upton, N. Y. Accelerator  
Dept.  
**SOLAR-POWERED STEAM GENERATOR HELIOSTAT Final  
Report**

J. G. Cottingham Dec. 1978 143 p refs  
(Contract EY-76-C-02-0016)  
(BNL-50974) Avail: NTIS HC A07/MF A01

A small-size central-receiver-type solar energy collecting system delivering commercial grade steam is analyzed and a wind avoidance type heliostat designed, built, and successfully tested. The heliostat design effort is described, including reflecting surface materials and measurements, optic considerations and mirror field arrangements, mechanical analysis and fabrication techniques, and economics and cost effectiveness. Measurements of normal incident solar energy at Upton, N. Y., are reported and a method is proposed for estimating this input parameter for other locations proposed. DOE

**N79-31809/** Battelle Pacific Northwest Labs., Richland, Wash.  
**HELIOSTAT REFLECTIVE SURFACE SUBSTRATE CHARACTERIZATION**

N. R. Gordon Nov. 1978 29 p refs  
(Contract EY-76-C-06-1830)  
(PNL-2810) Avail: NTIS HC A03/MF A01

Reflective surface substrates were characterized and specifications tasks are presented. The properties of foam core sandwich construction were emphasized. The relationship between viscoelastic deformation of the adhesive and deflection of the mirror module was investigated. DOE

**ANALYSIS AND DESIGN OF A FIELD OF HELIOSTATS FOR  
A SOLAR POWER PLANT**, by J. L. Abatut and A. Achaibou.  
Solar Energy, vol. 21, no. 6, 1978, p.453-463.

**Abstract**—For the design of the mirror field for the CNRS (Centre National de la Recherche Scientifique) project of a several MWe solar energy conversion power plant, an analysis of this concentration system is proposed. Using simulation programs, the problems of the choice of an optimal height of the tower and a convenient slope of the field are solved. By analysing the variation of the thermal power during five test days, it is shown that subject to certain assumptions the maximum output power is about 10 MWe.

**N78-33800/** National Technical Information Service, Springfield,  
Va.

**HELIOSTAT SYSTEMS DESIGN AND OPERATION. CITATIONS FROM THE ENGINEERING INDEX DATA BASE  
Progress Report, 1970 - Jun. 1978**

Audrey S. Hundemann Aug. 1978 44 p  
(NTIS/PS-78/0842/1) Avail: NTIS HC \$28.00/MF \$28.00  
CSCL 10A

The design and use of heliostats in solar central receiver thermal power systems are discussed in abstracts from worldwide literature. Topic areas include heliostat systems performance, efficiency, and optimization. Emphasis of the bibliography is on basic research. This bibliography contains 38 abstracts. GRA

**Heliostats**

1978

**COMPUTER BASED SUN FOLLOWING SYSTEM**, by B. P. Edwards.  
Solar Energy, vol. 21, no. 6, 1978, p.491-496.

**Abstract**—This paper is a design study of a computer based system which controls a large number of paraboloidal collectors for sunfollowing operation. The system operates with the computer changing the speeds of each of the collector actuators in the field at regular intervals over the day. It is assumed that each collector requires individual attention in the calculation of appropriate speeds. Sources of following error within the system are evaluated, and for specific data rates over the communication link between the central controller and the field of collectors, the variables within the system are chosen to minimise the following error. Accurate sun following is shown to require a data output from the central controller of only 500 bit/sec for 10,000 collectors.

Further a computer based learning procedure which is functionally equivalent to an alignment process is detailed. This procedure is implemented by collecting data from each collector in the field. Accurate "alignment" of a 10,000 collector field is shown to require data collection by the central controller at a rate of only 500 bit/sec for a single day. No new technology is required to accommodate the data rates mentioned.

## SOLAR - HEATING AND COOLING BUILDINGS

### Power sources, Solar - Heating & cooling

The National Solar Heating and Cooling Information Center has a reading list numbering over 40 technical and non-technical books and periodicals for the solar buyer.

They can be reached at P.O. Box 1607, Rockville, Md. 20850.

The Information Center is operated by the Franklin Institute, Department of Housing and Urban Development and the Energy Research and Development Administration.

**N79-25503\*** Contemporary Systems, Inc., Jaffrey, N. H.  
**SOLAR HEATING SYSTEM FINAL DESIGN PACKAGE**  
May 1979 69 p. Prepared for DOE  
(Contract NAS8-32243)  
(NASA-CR-161228) Avail: NTIS HC A04/MF A01 CSCL 10A

The system is composed of a warm air collector, a logic control unit and a universal switching and transport unit. The collector was originally conceived and designed as an integrated roof/wall system and therefore provides a dual function in the structure. The collector serves both as a solar energy conversion system and as a structural weather resistant skin. The control unit provides totally automatic control over the operation of the system. It receives input data from sensor probes in collectors, storage and living space. The logic was designed so as to make

maximum use of solar energy and minimize use of conventional energy. The transport and switching unit is a high-efficiency air-handling system equipped with gear motor valves that respond to outputs from the control system. The fan unit was designed for maximum durability and efficiency in operation, and has permanently lubricated ball bearings and excellent air-handling efficiency.

R.E.S.

### STANDARDIZATION IN SOLAR ENERGY. G.T. Pytlinski

Standardization News, vol 7, no 8, August 1979, p. 8-12.

In the current climate of energy shortages and soaring fuel costs, solar energy is receiving more and more ~~the~~ attention from industry, the government, and the consuming public as an alternative to fossil fuels. And that puts the spotlight on solar standardization, as a ~~the~~ prerequisite for the orderly development of the mushrooming solar market.

### AN OPTIMAL STANDARD FOR SOLAR HEATING SYSTEMS, D.M. Auslander, M. Tomizuka and H. Lee

Jour. of Dynamic Syst., Measure., and Cont., v.101,  
no.2, June 1979, p.138-

Control problems in solar heating systems are studied. Using a load temperature regulation specification based on minimum temperature, an optimal control problem is formulated to compute a lower bound on the amount of auxiliary energy needed, over a given cycle, for a fixed solar heating system. In order to estimate the sophistication of control necessary for achieving higher performance, a comparative study is made among several simple controllers with both proportional and on-off actuation.

**CASE HISTORY-HYBRID PASSIVE/ACTIVE SOLAR SYSTEM:**

**PERFORMANCE AND COST**, by Bruce D. Hunn.

ASHRAE Journal, vol. 21, no. 4, April 1979, p.25-30.

*The design, construction, cost, and initial operation of a hybrid passive/active solar-heated house in Los Alamos, NM, is described. The system is dominated by a two-story Trombe wall, constructed of 0.3-m-thick (1-ft) slump block, that can be operated in either a passive or active mode. In the active mode, a blower circulates air through the Trombe wall air space and into a rock bed. A three-zone forced-air distribution system is connected to the rock bed. A separate flat-plate collector array heats a preheater tank for domestic hot water. Energy consumption records indicate that approximately 60% of the net space heating load was provided by solar energy. This paper was presented at a Symposium on Passive Solar Systems during ASHRAE's 1979 Semiannual Meeting in Philadelphia, PA, and will appear unabridged in ASHRAE Transactions, Vol. 85, Part 1.*

**PUMPS FOR SOLAR SYSTEMS**, by Douglas Bingler.

Solar Heating & Cooling, vol. 4, no. 3, April 1979, p.27-29.

Among the many types of solar systems that are presently being installed, there exist specific and individual system design and application parameters that must be considered for proper pump selection. The construction and performance of the pumps to be selected must satisfy the system design to assure optimal efficiency and dependability of the system. Specific pump information pertaining to the materials of construction, pumping capacities, power consumption, and recommended systems applications should be obtained for each system to be considered. By relying upon the expertise that exists among the many pump manufacturers, information can be provided to assist in the pump selection.

NASA CR-3111 Power sources, Solar - 1979  
Heating & cooling

**AN ANALYTICAL INVESTIGATION OF THE PERFORMANCE OF SOLAR COLLECTORS AS NIGHTTIME HEAT RADIATORS IN AIRCONDITIONING CYCLES.** Clay B. Jones and Frederick O. Smetana. Mar.1979. 60p.

North Carolina Science and Technology  
Research Center, Research Triangle Park  
NASA NAS1-14208

**SOLAR ENERGY: FOUR SITES DEMONSTRATE POTENTIAL.**

IEEE Spectrum, vol 16, no 4, April 1979, p. 67-65.

**CUANDO: SOLAR WALL HEATS A GYM**, by Jane Wholey.

Popular Science, vol. 214, no. 2, Feb. 1979, p.24-26.

New York City's first solar air heater is now complete. Built on the south-facing wall of a block-long community center named CUANDO (Cultural Understanding and Neighborhood Development Organization), the solar wall needs no assistance from electricity to power its machinery. It depends solely on the natural flow of thermal energy to heat the gymnasium behind its collectors.

**PREDICTION OF THE PERFORMANCE OF SOLAR HEATING SYSTEMS OVER A RANGE OF STORAGE CAPACITIES.** R. J. Lunde.

Solar Energy, vol 23, no 2, 1979, p. 115-121.

**Abstract**—A new method for prediction of the performance of solar heating systems using well-mixed storage is presented which predicts monthly and annual system performance (relative to a computer simulation) over a wide range of system variables including minimum or base storage temperature, storage capacity, and geographic location. The method relies on heavily pre-processed site-specific radiation and weather data which is used with system properties to predict the quantities necessary for correlation. The method yields long-term monthly and annual performance predictions which are so accurate that they can serve simultaneously for preliminary design, economic optimization, and final design, eliminating the need for simulation.

**TROMBE WALL DESIGN MANUAL**, by Alex Wilson.

Solar Utilization News, vol. 3, no. 8, February 1979, p.8&9

**FREE CONVECTIVE LAMINAR FLOW WITHIN THE TROMBE WALL CHANNEL**, by H. Akbari and T.R. Borgers, Solar Energy, vol. 22, no. 2, 1979, p.165-175.

**Abstract**—Free convective laminar heat transfer between the channel surfaces of the Trombe wall has been investigated. Considered in this study were the velocity profiles normal and parallel to the direction of fluid flow the pressure drop due to flow acceleration at the channel entrance, and the effect of dissimilar but uniform channel surface temperatures for a wide range of flow rates and temperatures.

A finite difference procedure was used to solve the governing equations in dimensionless form using air as the fluid. After comparison with available experimental data, results have been reduced, and several correlations developed to enable important performance characteristics to be estimated given the channel thickness, height, and surface temperatures.

**N79-32708** Los Alamos Scientific Lab., N. Mex.  
**PASSIVE SOLAR HEATING FOR BUILDINGS**  
J. Douglas Balcomb 1979 16 p Presented at the Workshop on Passive Solar Design, Perth, Australia, 23 Feb. 1979  
(Contract W-7405-eng-36) Avail: NTIS  
(LA-UR-78-427; Conf-790224-1) HC A02/MF A01

A passive solar energy system is one in which the thermal energy flow is by natural means, that is by radiation, conduction, or natural convection. A survey of passive solar heating experience, especially in the U.S., is provided. Design approaches are reviewed and examples shown. Misconceptions are discussed. Advantages are listed. The Los Alamos program of performance simulation and evaluation is described and a simplified method of performance estimation is outlined. DOE

**SOLAR: A HOT ITEM THAT'S COOL, TOO**, Environment Science & Technology, vol. 13, no. 3, March 1979, p.269-270.

*Honeywell is using it to meet the major portion of its General Offices building's heating, hot water, and air conditioning needs*

**SOLAR WALL PERFORMANCE.** J. Cash

International Journal of Energy Research, vol 2, no 3, July-September 1978, p. 229-245.

The basic solar wall consists of an opaque inner leaf and a transparent outer leaf. According to one-dimensional heat transfer theory the thermal behaviour of the wall can be described using a wall thermal transmittance, a solar gain factor and an environmental temperature. Tests on small units at Bolton Street, Dublin during the period 3-13 April 1976, are supportive of the theory. As well as test results this paper includes radiation measurements made during the period.

**N79-31805** Midwest Research Inst., Golden, Colo.  
**CLASSIFICATION SCHEME FOR THE COMMON PASSIVE AND HYBRID HEATING AND COOLING SYSTEMS**  
Michael J. Holtz, W. Place (California Univ., Berkeley, Lawrence Berkeley Lab), and R. C. Kammerud (California Univ., Berkeley, Lawrence Berkeley Lab) Feb. 1979 9 p refs Presented at 3d Natl Passive Solar Conf., San Jose, Calif., 11 Jan. 1979  
(Contract W-7405-eng-48)  
(LBL-8814; Conf-790118-6) Avail: NTIS HC A02/MF A01

A systematic nomenclature and classification scheme is proposed for passive space heating and cooling systems. It is based upon the mode of energy transport to and from the space and the environmental resource from which the energy is received or to which it is discharged. A number of passive and hybrid space heating and cooling systems are characterized. DOE

**N79-27883** California Univ., Berkeley, Lawrence Berkeley Lab.  
**MODELING PASSIVE SOLAR BUILDINGS WITH HAND CALCULATIONS**  
David B. Goldstein 1979 9 p refs Presented at 3d Natl. Passive Solar Conf., San Jose, Calif., 11-13 Jan. 1979  
(Contract W-7405-eng-48)  
(LBL-8583; Conf-790108-3) Avail: NTIS HC A02/MF A01

An analytic model of passive solar building performance was derived. Heat balances were used on the surfaces of materials that absorb sunlight along with solutions to the diffusion equation, to derive response functions for surface temperature as a function of solar flux and ambient temperature. These expressions are combined to form building response functions. These explicit building response functions allow one to write relatively simple, analytic expressions for room temperature as a function of time

**N79-28754** Los Alamos Scientific Lab., N. Mex.  
**TROMBE WALL VS DIRECT GAIN: A COMPARATIVE ANALYSIS OF PASSIVE SOLAR HEATING SYSTEMS**  
William O. Wray and J. Douglas Balcomb 1979 8 p refs Presented at the 3d Natl Passive Solar Conf., San Jose, Calif., 11-13 Jan. 1979  
(Contract W-7405-eng-36)  
(LA-UR-116; Conf-790106-2) Avail: NTIS HC A02/MF A01

The results of performance analysis calculations for both Trombe wall and direct gain systems in Albuquerque, New Mexico, and Madison, Wisconsin, are reported. The comparative analysis included parametric variation of fundamental design parameters including building load, glazing area, total mass, mass thickness, number of glazings, night insulation value and allowable temperature swing. Thermal comfort within the two generic types of buildings was considered as well as energy efficient performance. DOE

## THE "SUNBURST" SOLAR HOME.

The Mother Earth News, no. 55, Jan/Feb 1979, p.109-110.

Recently, one of MOTHER's staffers and a photographer went to Landenberg, Pennsylvania to look at one of the "simple" systems and to talk to its designer—produce-salesman-turned-builder Jim Kries—who is in the process of constructing a small community of passively heated solar houses . . . which he very appropriately calls "Sunburst" homes.

Mind you, though, these houses don't utilize what you might call your "average" solar collector. Instead, Jim has opted to incorporate a "Trombe wall" (named after its inventor, French physi-

cist Felix Trombe), which not only heats the house without any moving parts or expensive equipment, but makes the dwelling as attractive (at least!) as any custom-built conventional home. In fact, the owners of the house—Vincent and Kathy Polidoro—decided to buy it when they saw the blueprints . . . before construction of the home had even begun. And, after talking to the Polidoros, we're convinced that they haven't been disappointed at all!

**A79-44504** Passive solar heating for buildings. J. D. Balcomb (California, University, Los Alamos, N. Mex.). In: The passive collection of solar energy in buildings; Proceedings of the Conference, Royal Institution of Great Britain, London, England, April 24, 1979. Conference sponsored by the International Solar Energy Society, London, International Solar Energy Society, 1979, p. 75-85. 11 refs. Research sponsored by the U.S. Department of Energy and Office of the Assistant Secretary for Conservation and Solar Applications.

A survey of passive solar heating experience is presented. Design approaches reviewed include: (1) direct gain, (2) thermal storage wall, (3) attached sun space, (4) thermal storage loops, and (5) convective loop. Consideration is also given to generic categories: (a) direct, (b) indirect, and (c) isolated. Data is given showing that passive heating can be successful in regions such as Boston, Mass. and Seattle, Wash. Advantages cited include low cost, ease of natural operation, thermal comfort, few needs for certification, and esthetic appeal. The Los Alamos program of performance simulation and evaluation is described and a simplified method of performance estimation is outlined. M.E.P.

**N80-10849** Los Alamos Scientific Lab., N. Mex. **SIMPLE PROCEDURE FOR ASSESSING THERMAL COMFORT IN PASSIVE SOLAR HEATED BUILDINGS** William O. Wray 1979 6 p refs Presented to Intern. Solar Energy Soc. Meeting, Atlanta, Ga., 28 May 1979 (Contract W-7405-eng-36) (LA-UR-79-1337; Conf-790541-5) Avail: NTIS HC A02/MF A01

A thermal comfort equation, a procedure for assessing thermal comfort levels in passive solar heated buildings is presented. A thermal index called the equivalent uniform temperature is introduced to relate comfort levels in nonuniform environments to uniform conditions. DOE

**A79-44295** How a wall uses solar energy (Comment un mur utilise-t-il l'énergie solaire). F.M. Camia (Ecole d'Architecture de Luminy, Marseille, France). *Coopération Méditerranéenne pour l'Energie Solaire, Revue Internationale d'Héliotechnique*, 1st Semester, 1979, p. 11-17. 7 refs. In French.

The captation of solar energy by opaque walls is analyzed. A simple formulation of the transfer function for a wall is obtained on the basis of the assumption that the latter can be represented as the sum of a constant mean energy and a sinusoidal variation. These expressions are used to evaluate the coupled effects of conduction and convection. The elements of the intrinsic reaction of the wall are calculated and directly applied to time tables of the energy received. The analysis indicates that the energy transfer regime is strongly influenced by the value of the coefficient of external exchange. It also shows that convection is a serious obstacle to captation of solar energy by walls. C.K.D.

**N79-28729** Garden State Racing Association, Cherry Hill, N. J. **SOLAR HEATING AND HOT WATER SYSTEM INSTALLED AT CHERRY HILL, NEW JERSEY** 16 May 1979 299 p Sponsored by NASA (Contract EG-77-A-01-4086) (NASA-CR-161235) Avail: NTIS HC A11/MF A01 CSCL 10A

The solar heating and hot water system installed in existing buildings at the Cherry Hill Inn in Cherry Hill, New Jersey is described in detail. The system is expected to furnish 31.5% of the overall heating load and 29.8% of the hot water load. The collectors are liquid evacuated tube type. The storage system is an above ground insulated steel water tank with a capacity of 7,500 gallons. R.E.S.

## PERFORMANCE EFFECTS OF TROMBE WALL CONTROL STRATEGIES

A.V. Sebald, J. R. Clinton and F. Langenbacher

Solar Energy, vol. 23, no. 6, 1979; pp. 479-487.

**Abstract**—Trombe wall performance is analyzed for a variety of control strategies in Albuquerque, New Mexico, Santa Maria, California and Madison Wisconsin. Controls were considered in both the presence and absence of backup energy. The analysis was performed using hourly simulations on Solmet weather data in a thermal network model. Sensitivity of the results to wall thickness and size, building azimuth and house insulation levels is computed.

Proper controls were found to reduce backup requirements as much as 50 per cent. Alternatively, they appear to provide equivalent solar fractions with thinner and smaller walls. Finally, in the absence of backup energy, proper controls on thin walls provide better performance than standard walls of double thickness.

The results given in this paper are based entirely on computer simulations and are therefore intended to enhance the reader's insight into the Trombe Wall control problem. Efforts are underway to verify the major conclusions in test structures and real houses.

**INITIAL EXPERIMENTAL TESTS ON THE USE OF SMALL PASSIVE-SOLAR TEST-BOXES TO MODEL THE THERMAL PERFORMANCE OF PASSIVELY SOLAR-HEATED BUILDING DESIGNS.** D.P. Grimmer, R.D. McFarland and J.D. Balcomb.

Solar Energy, vol 22, no 4, 1979, p. 351-354.

**Abstract**—Small passive-solar test-boxes can be a useful tool in the thermal-modelling of a passively solar-heated building designs. Several cubic-meter sized test-boxes have been constructed that incorporate basic elements of passive-solar design: glazings to admit solar radiation, good thermal insulation, and large thermal storage capacity within the insulation-envelope. The experimental thermal behavior of these test-boxes has been accurately computer simulated using weather and solar radiation data inputs, and correlated with the performance of large passive test rooms nearby. Similar small test boxes can be constructed to perform as thermal models of a particular passive-solar building design, by normalizing the appropriate thermal design parameters to one critical parameter, such as south-facing glazing area, or building floor area. Thus a thermal model will not resemble a scaled architectural model of the building, but will be distorted in appearance so as to exhibit thermal behavior similar to the real building. For a particular passive-solar building design to be located at a given site, a small thermal model of the building can be constructed and placed at the site to investigate possible micro-climate effects, such as a south-facing slope or nearby trees. The use of small passive-solar test-boxes complements simulation analyses of the influence of macro-climate and geometry on the performance of passive solar heated buildings. The accuracy and limitations of using small test-boxes to predict passive-solar building performance are discussed.

**N79-28756/** Los Alamos Scientific Lab., N Mex  
**PERFORMANCE AND COST OF A HYBRID PASSIVE/ACTIVE SOLAR HOUSE**  
B. D. Hunn 1979 26 p refs Presented at the ASHRAE Symp. on Air Infiltration, Philadelphia, Jan. 1979  
(Contract W-7405-eng-36)  
(LA-UR-78-2209, Conf 790112-4) Avail. NTIS HC A03/MF A01

The design, construction, cost, and initial operation of a hybrid passive/active solar heated house in Los Alamos, New Mexico, is described. The system is dominated by a two-story Trombe wall, constructed of 0.3 m thick (1 ft) slump block, that can be operated in either a passive or active mode. In the active mode, a blower circulates air through the Trombe wall air space and into a rock bed. A three zone forced air distribution system is connected to the rock bed. A separate flat plate collector array heats a preheater tank for domestic hot water. Operating results of the system are reported for just over the first year of operation. In addition, system cost, occupant observations, and conclusions are presented. Energy consumption records indicate that approximately 60% of the net space heating load was provided by solar energy. DOE

**N80-14545/** Department of Energy, Washington, D. C.  
**COMMERCIALIZATION STRATEGY REPORT FOR SOLAR WATER HEATING**  
Frederick H. Morse and J. M. Davis [1979] 35 p refs  
(TID-28856-Draft) Avail. NTIS HC A03/MF A01

The commercial readiness of solar hot water heating is discussed. Some barriers to be overcome before this technology is ready to be used commercially are identified. Also identified are possible actions that might be considered to remove specific barriers. Technical, market/economics, environmental, and institutional readiness, and benefits analysis are discussed. DOE

**N79-29834/** Los Alamos Scientific Lab., N Mex Systems, Analysis, and Assessment Div.

**TROMBE WALLS AND DIRECT GAIN: PATTERNS OF NATIONWIDE APPLICABILITY**

Scott A. Noll, J. Fred Roach, and Shaul Ben-David (New Mex. Univ., Albuquerque) 1979 9 p refs Presented at 3d Natl Passive Solar Conf., San Jose, 11-13 Jan. 1979

(Contract W-7405-eng-36)

(LA-UR-79-239; Conf-790106-5)

Avail. NTIS

HC A02/MF A01

The economic performance of Trombe wall and direct gain passive solar heating designs are evaluated on a nationwide basis using the LASL/UNM solar economic performance code. Both designs are integrated into a ranch style tract home concept thereby facilitating regional comparisons. Solar add-on costs are established for each design with regional differences in material and labor prices accounted for at each site. System sizes are optimized against the natural gas and electric resistance heating

alternatives, the current price and future escalation of which is established for each locale. Results for each passive solar design are summarized on a state-by-state basis followed by a discussion of their comparative economic performance. DOE

**PASSIVE SOLAR HEATING OF BUILDINGS USING A TRANSWALL STRUCTURE.** R. Fuchs, and J. F. McClelland.

Solar Energy, vol 23, no 2, 1979, p. 123-128.

**Abstract**—Passive solar heating systems can utilize a number of design approaches, but the most prominent ones are those employing "direct gain" or a "Trombe thermal storage wall". In this work we propose a new passive system employing a "transwall", which is a partially transparent thermal storage wall placed adjacent to a window admitting solar energy. Part of the solar energy is absorbed within the transwall, and the remaining part is transmitted to the interior of the room. The transwall is architecturally more attractive than the completely absorbing Trombe wall, since it admits light to the room and allows the occupants to see out through the window without glare and overheating problems of direct gain systems.

Calculations using thermal network models and based on reasonable assumptions for relative comparisons have been used to compare thermal performance of transwall, Trombe wall, and direct gain systems. The analysis shows that the transwall system can be expected to have thermal performance very close to or exceeding the other systems, depending on how effectively convective heat transfer is quenched in the thermal storage medium.

The important question of visual clarity for the transwall system has been evaluated for a prototype by photographing a scene with and without optical transmission through the structure. Optical distortion is minimal in the transwall transmission photograph.

**N80-17558/** Franklin Research Center, Philadelphia, Pa  
**FIRST PASSIVE SOLAR HOME AWARDS**

Jan. 1979 229 p refs

(Contract EX-76-A-29-1020)

(DSE-1020-T17) Avail. NTIS HC A11/MF A01

One hundred and sixty two solar home projects are listed and described. The projects are divided into three general categories: direct solar gain, indirect solar gain, and solarium. Discussions on selecting the best type of solar project for a given area, issues involved in marketing passive solar homes, and calculating the solar gain from passive systems are included. AWH

## AN EXPERIMENTAL STUDY OF CORRUGATED STEEL SHEET SOLAR WATER HEATER

Wang Shing-An

Solar Energy, vol. 23, no. 4, 1979, pp. 333-341.

**Abstract** - An analysis of the heat transfer process in the corrugated steel sheet solar water heater and a simplified test procedure for determining the collector efficiency equation are presented. By experiment, the collector efficiency equation is found to be  $\eta = 0.68 - 7(T_c - T_a)/I$ , the efficiency factor of collector is over 0.94, and the space temperature is 7°C higher than the collector temperature. The efficiency equation obtained by the simplified procedure coincides with that obtained by the standard procedure.

**A80-21105** Performance effects of Trombe wall control strategies. A. V. Sebald, J. R. Clinton, and F. Langenbacher (California, University, La Jolla, Calif.). *Solar Energy*, vol. 23, no. 6, 1979, p. 479-487. 12 refs. Contract No. EM-76-S-04-4221.

Trombe wall performance is analyzed for a variety of control strategies in Albuquerque, New Mexico, Santa Maria, California and Madison, Wisconsin. Controls were considered in both the presence and absence of backup energy. The analysis was performed using hourly simulations on Solmet weather data in a thermal network model. Sensitivity of the results of wall thickness and size, building azimuth and house insulation levels is computed. Proper controls were found to reduce backup requirements as much as 50 per cent. Alternatively, they appear to provide equivalent solar fractions with thinner and smaller walls. Finally, in the absence of backup energy, proper controls on thin walls provide better performance than standard walls of double thickness. The results given in this paper are based entirely on computer simulations and are therefore intended to enhance the reader's insight into the Trombe Wall control problem. Efforts are underway to verify the major conclusions in test structures and real houses. (Author)

## THEORETICAL CONSIDERATIONS IN THE USE OF SMALL PASSIVE-SOLAR TEST-BOXES TO MEASURE THE THERMAL PERFORMANCE OF PASSIVELY SOLAR-HEATED BUILDING DESIGNS. D.P. Grimmer.

Solar Energy, vol 22, no 4, 1979, p. 343-350.

**Abstract**—Theoretical considerations are presented for the thermal modelling of passively solar-heated building designs with passive-solar test boxes. Multi-room passive solar buildings, passive solar buildings having realistically massive walls, thermocirculating passive-solar designs, air-infiltration effects, edge effect corrections, and micro-climate shading effects are discussed.

A FIELD VALIDATION OF THE THERMAL PERFORMANCE OF A PASSIVELY HEATED BUILDING AS SIMULATED BY THE DEROB SYSTEM., by Francisco Arumi-Noe and David O. Northrup. *Energy and Buildings*, vol. 2, no. 1, January 1979, p.65-75.

Hourly thermal performance data for a passively solar heated house are compared with simulated data. The house, Solar Village 1, in Santa Fe, New Mexico, owned and occupied by the Douglas Balcomb family, has been instrumented and monitored since the 1976-77 winter. The data reproduced here were collected in February 1978, including on-site micro-climatic weather data. The simulation is carried out with the computer program DEROB as developed at the Numerical Simulation Laboratory of the School of Architecture of the University of Texas at Austin.

DEROB is a fully dynamic program, capable in principle of handling architectural designs of arbitrary geometry and simultaneously solving thermally coupled multi-space structures. Solar Village 1 is a 2 storey, L-shaped, hybrid structure with a glasshouse occupying the front court (south-facing) 2-storey volume. Hourly data include, in addition to micro-climatic information, temperature readings of the air in the glasshouse, of the air in the various living quarters, the temperature readings across the adobe walls that separate the living quarters from the glasshouse, and also the temperature of the two rock storage bins.

ADVENTURES IN ALTERNATE ENERGY, TWO SOLAR HEATERS, FOR AIR AND WATER, by Edward Moran. *Popular Science*, vol. 214, no. 1, January 1979, p. 46-48.



**ECONOMIC FEASIBILITY OF SOLAR WATER AND SPACE HEATING**, by Roger H. Bezdek, Alan S. Hirshberg, William H. Babcock.

Science, vol. 23, no. 4386, March 1979, p.1214-1220.

**Summary.** The economic feasibility in 1977 and 1978 of solar water and combined water and space heating is analyzed for single-family detached residences and multi-family apartment buildings in four representative U.S. cities: Boston, Massachusetts; Washington, D.C.; Grand Junction, Colorado; and Los Angeles, California. Three economic decision criteria are utilized: payback period, years to recovery of down payment, and years to net positive cash flow. The cost competitiveness of the solar systems compared to heating systems based on electricity, fuel oil, and natural gas is then discussed for each city, and the impact of the federal tax credit for solar energy systems is assessed. It is found that even without federal incentives some solar water and space heating systems are competitive. Enactment of the solar tax credit, however, greatly enhances their competitiveness. The implications of these findings for government tax and energy pricing policies are discussed.

**A80-18578 #** An optimization formulation for solar hot water systems. K. K. Chang and A. Minardi (Central Florida, University, Orlando, Fla.). *American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Dec. 2-7, 1979, Paper 79-WA/Sol-42.* 7 p. 6 refs. Members, \$1.50; nonmembers, \$3.00.

A mathematical correlation between collector area and auxiliary energy used in a solar hot water system was obtained by using TRNSYS program. Based on this correlation, optimum collector area was directly related to both economic factors and system parameters. A criteria for economic feasibility was obtained. A comparison of optimum area calculated by this analysis with optimum area based on f-chart data was in good agreement. (Author)

**A Markov model of solar energy space and hot water heating systems.** Gerald F. Lameiro, William S. Duff.

**Solar Energy.** v. 22, no. 3, 1979, p. 211-219.

**Abstract**—This paper presents a Markov model approach to the generalized solar energy space heating performance analysis problem. Specifically, Markov chain models are developed to represent ambient temperature, insolation, hot water load and system performance. From the Markov transition probability matrices for these variables, long-term expected performance is calculated. The theoretical development is implemented in FORTRAN IV on a Control Data 6400 Computer System. Computational experience gained, using STOLAR 3.1 (STochastic soLAR energy systems model), indicates the stochastic approach requires approximately five per cent of the time necessary for standard dynamic simulation approaches with comparable performance results. The method also compared favorably with FCHART, a simplified design procedure.

**SIMULATION OF THE IMPACT OF FINANCIAL INCENTIVES ON SOLAR ENERGY UTILIZATION FOR SPACE CONDITIONING AND WATER HEATING: 1985**, by H. Craig Petersen.

Energy and Buildings, vol. 2, no. 1, January 1979, p.77-84.

*Financial incentives designed to accelerate the use of solar energy for heating, cooling, and water heating of buildings have been proposed by both state and federal legislative bodies in the U.S.A. Among the most frequently mentioned incentives are sales and property tax exemptions, tax deductions and credits, rapid amortization provisions, and interest rate subsidies. At the present time there is little available information regarding the ability of such incentives to advance the rate of solar energy utilization. This paper describes the derivation and use of a computer simulation model designed to estimate solar energy use for space conditioning and water heating for given economic, climatic, and technological conditions. When applied to data from the Denver, Colorado metropolitan area, the simulation model predicts that sales tax exemptions would have little impact over the next decade, interest rate subsidies could more than double solar energy use, and the other proposed incentives would have an intermediate impact.*

**N80-17566#** Sandia Labs., Albuquerque, N. Mex.  
**PERFORMANCE OF SOLAR PASSIVE BUILDINGS**  
R P Stromberg 1979 20 p refs Presented at the First Intern. Symp. on Non-conventional Energy, Trieste, Italy, 27 Aug. - 7 Sep 1979  
(Contract EY-76-C-04 0789)  
(SAND-79-1574C; CONF-790850-2) Avail: - NTIS  
HCA02/MFA01

Test data are presented for five different homes during the same winter days. Trombe wall, waterwall, greenhouse, and direct gain features of the buildings display their differing responses to the same climate conditions. DOE



**SOLAR HEATING SYSTEM PERFORMANCE ESTIMATION USING SINUSOIDAL INPUTS**

M. S. Drew and R. B. G. Selva

Solar Energy, vol. 23, no. 5, 1979, pp. 435-442.

**Abstract**—A method is presented for the estimation of the fraction of the heating load supplied by solar energy during the heating season. This procedure remains useful even when system design parameters are far from the norm, and in particular is applicable to systems incorporating seasonal storage of heat. Insolation, temperature and hot water demand are input as sinusoids, and the closed-form solution of the heat transfer differential equation is found. The method as presented here is suitable for domestic hot water and liquid space heating systems.

**NUMERICAL COMPUTATION OF SINGULAR CONTROL PROBLEMS WITH APPLICATION TO OPTIMAL HEATING AND COOLING BY SOLAR ENERGY**

Hans Joachim Oberle

Applied Mathematics and Optimization, vol. 5, no. 4, 1979, pp. 297-314.

**Abstract.** The method presented here is an extension of the multiple shooting algorithm in order to handle multipoint boundary-value problems and problems of optimal control in the special situation of singular controls or constraints on the state variables. This generalization allows a direct treatment of (nonlinear) conditions at switching points. As an example a model of optimal heating and cooling by solar energy is considered. The model is given in the form of an optimal control problem with three control functions appearing linearly and a first order constraint on the state variables. Numerical solutions of this problem by multiple shooting techniques are presented.

**Installing Your First Solar System**

by R.H. Montgomery

Solar Heating & Cooling, Vol. 4, No. 4, June 1979, p. 17-21

**Part 2:**

Solar Heating & Cooling, Vol. 4, No. 5, August 1979, p. 37-40

**Solar Control Installation Instruction Guide**  
by S. Dawson

Solar Heating & Cooling, Vol. 4, No. 5, August 1979, p. 26-30

**THERMODYNAMIC BASIS FOR THE CHOICE OF WORKING FLUIDS FOR SOLAR ABSORPTION COOLING SYSTEMS.**

G. Ali Mansoori and Vinod Patel

Solar Energy, Vol 22, no 6, 1979, p.483-491.

**Abstract**—Through the application of the first and second laws of thermodynamics upper and lower limits for the coefficient of performance (COP) of absorption cooling cycles are derived. These upper and lower limits, besides being dependent on the environmental temperatures of components of the cycle, are also dependent on the thermodynamic properties of refrigerants, absorbents, and their mixtures. With the use of these upper and lower limits of COP it is now possible to make a quantitative comparative study of different refrigerant-absorbent combinations. The technique developed is applied for the comparative evaluation of  $\text{NH}_3 + \text{H}_2\text{O}$ ,  $\text{NH}_3 + \text{NaSCN}$  and  $\text{H}_2\text{O} + \text{LiBr}$  combinations which are the favorable candidates used in solar absorption cooling cycles.

**HEAT TRANSFER FLUIDS, MAKING A "FLUID" CHOICE,** by Thomas J. Tragert.

Solar Heating & Cooling, vol. 4, no. 1, Feb. 1979, p.30-32- con't on pg. 41.

Sometime during the design, specification, and installation of a solar heating system, a choice must be made as to the type of heat transfer fluid to be used. Many types of specific "solar" heat transfer fluids are now commercially available. An even greater number of fluids compatible with today's solar applications are, and have been, available for many years. Choosing is often difficult. The following guidelines can help in making a "fluid" choice.

**SIZING PHASE-CHANGE ENERGY STORAGE UNITS FOR AIR-BASED SOLAR HEATING SYSTEMS.** J.J. Jurinak and S.I. Abdel-Khalik.

Solar Energy, vol 22, no 4, 1979, p. 355-359.

**Abstract**—A simple method for sizing phase-change energy storage (PCES) units for air-based solar heating systems is presented. An effective heat capacity for the phase change unit is obtained as a function of its mass, latent heat, specific heat, and melting temperature. The effective heat capacity can then be used, along with any convenient design method for systems with sensible heat stores, such as the *f*-chart method, to estimate the thermal performance of the system utilizing PCES.

**TRACKING SOLAR HEATER USES TAP WATER TO KEEP ITS FACE TO THE SUN.**

David Scott.

Popular Science, vol 214, no 6, June 1979, p. 82-83.

**Installing your first Solar Syatem.** Richard H. Montgomery.. (continued in next issue).

Solar Heating & Cooling. v. 4, no. 4, June 1979, p.17-21

**A79-37851** Domestic space and water heating for existing dwellings using a heat pump and conventional roofs as energy absorbers. W. E. J. Neal and D. L. Loveday (Aston, University, Birmingham, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 57-60, 6 refs. Research supported by the Science Research Council.

**A79-37888** Solar heating and cooling systems - Practical experience in design and operation. D. J. Gilby and R. Minder. In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 256-259.

Experience gained in the design and operation of a solar cooling test facility has been successfully applied in designing a large solar system. This installation will deliver part of the thermal energy required by an industrial plant located near Rome. The system, backed up by an oil fired boiler, will provide heating during the winter months, cooling during the summer months, and hot water during the whole year. B.J.

**DESIGN CONSIDERATIONS FOR RESIDENTIAL SOLAR HEATING AND COOLING SYSTEMS UTILIZING EVACUATED TUBE SOLAR COLLECTORS,** by Dan S. Ward and John C. Ward, Solar Energy, vol. 22, no. 2, 1979, p.113-119.

**Abstract**—As solar heating systems become a commercial reality, greater efforts are now being employed to incorporate solar cooling components in order to obtain a complete solar heating and cooling system and thus take advantage of the cost-effectiveness of year-round use of the solar equipment. Because of the exceptional performance and high efficiency of evacuated tube solar collectors, these advanced collectors are receiving considerable attention for use in solar heating and cooling systems. While improved performance is readily obtained with these sophisticated solar collectors, there are also numerous difficulties and problems associated with their use in a solar system. This paper addresses many of the design considerations which must be included in any realistic solar system design. Most of the considerations presented here are based on the experience gained in the design and performance of the solar heating and cooling systems for CSU Solar Houses I-IV.

**DESIGN STUDY: SOLAR SYSTEMS FOR COMMERCIAL BUILDINGS.** Ashrae Journal, vol 21, no 5, May 1979, p. 37-42.

**NASA CR-3112**

**1979**

**RESULTS OF HEATING MODE PERFORMANCE TESTS OF A SOLAR-ASSISTED HEAT PUMP.** Clay B. Jones and Frederick O. Smetana. Apr.1979. 81p.

North Carolina Science and Technology  
Research Center, Research Triangle  
NASA NAS1-14208

**CN-150,632** 1979  
**NASA TECHNOLOGY UTILIZATION HOUSE: SUMMARY OF RESULTS AND HOUSE DESCRIPTION. (Technical Support Package for Tech Brief LAR-12134).**  
1979. 78p.

**NASA,**  
**Langley Research Center**  
**NASA,**  
**Langley Research Center**

**LAR-12134**

**Buildings, Solar**  
**Buildings - NASA**

**ND0-11559\*** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.  
**AN EVALUATION OF THE NASA TECH HOUSE, INCLUDING LIVE-IN TEST RESULTS, VOLUME 1**  
Ira H. A. Abbott, Kenneth A. Hopping, and Warren D. Hypes  
Nov. 1979 72 p refs  
(NASA-TP-1564; L-13440) Avail: NTIS HC A04/MF A01 CSCI 10A

The NASA Tech House was designed and constructed at the NASA Langley Research Center, Hampton, Virginia, to demonstrate and evaluate new technology potentially applicable for conservation of energy and resources and for improvements in safety and security in a single-family residence. All technology items, including solar-energy systems and a waste-water-reuse system, were evaluated under actual living conditions for a 1 year period with a family of four living in the house in their normal lifestyle. Results are presented which show overall savings in energy and resources compared with requirements for a defined similar conventional house under the same conditions. General operational experience and performance data are also included for all the various items and systems of technology incorporated into the house design. Author

**NASA TP-1564, v.II**

**1979**

**AN EVALUATION OF THE NASA TECH HOUSE, INCLUDING LIVE-IN TEST RESULTS. VOLUME II.** Ira H.A. Abbott, Kenneth A. Hopping and Warren D. Hypes, LaRC.  
Dec. 1979. 68p.

Volume I of this paper includes a description and evaluation of the NASA Tech House, whereas Volume II includes supplementary data and information that may be of use in a serious study of the house. This information includes the monthly electrical usage and its cost, weather information, infrared scans of the house, daily meter readings, a listing of sensors used to provide data to the automatic data system, a listing of the calculator program, and tables of the condition of the gray water being reused as flush water.

**DESIGN AND OPERATION OF THE HONEYWELL GENERAL OFFICES SOLAR HEATING AND AIR CONDITIONING SYSTEM.**

Building Systems Design, vol 76, no 3, April/May 1979, p. 3-11.

The nation's largest high-temperature solar energy system has begun operating this winter — designed, funded and built by Honeywell for its new eight-story office building in Minneapolis. A field of 252 trough-like collectors on an adjacent parking ramp track the sun, concentrating its rays on liquid-filled pipes. Energy thus collected is expected to supply 50% of heating, 80% of cooling and 100% of hot water requirements for the 106,000-sq-ft building, where approximately 500 persons will work. The entire system will save the equivalent of 17,000 gal of oil annually based on operation under Minneapolis weather conditions.

Giant Solar-Energy System  
by R. Stepler

Popular Science, Vol. 215, No. 2, August 1979, p. 50-53, 118

Honeywell sets an energy-saving example for office buildings of the future.

**SOLAR ATTIC HOUSE**, by Richard Stepler.  
Popular Science, vol. 214, no. 1, January 1979  
p. 68-71.

**Unique two-chamber attic heats and cools a home designed by U.S. Dept. of Agriculture researchers**

# REDUCING INSTITUTIONAL BARRIERS TO SOLAR ENERGY THROUGH THE USE OF COOPERATIVELY-OWNED SOLAR ENERGY SYSTEMS. Michael B. Packer.

Energy, vol 4, no 3, June 1979, p. 383-392.

Abstract—Despite the conceptual attractiveness of solar energy systems for space heating applications, the market penetration rate of solar systems remains low. The physical, economic, and institutional barriers to acceptance that cause this disappointing performance are closely related to the present political, social, and economic structure, and to the prevailing difficult and time-consuming to lower. However, by using cooperative systems into larger cooperative ventures can avoid many of these barriers altogether. This "product fit" approach could greatly increase the diffusion rate of solar energy systems into these areas, thereby replacing fossil-fuel uses sooner and to a greater extent than previously expected.

# ECONOMIC EVALUATION AND OPTIMIZATION OF SOLAR HEATING SYSTEMS. M. J. Brandemuehl and W. A. Beckman.

Solar Energy, vol 23, no 1, 1979, p. 1-15.

Abstract—A procedure is developed for assessing the economic viability of a solar heating system in terms of the life cycle savings of a solar heating system over a conventional heating system. The life cycle savings is expressed in a generalized form by introducing two economic parameters,  $P_1$  and  $P_2$ , which relate all life cycle cost considerations to the first year fuel cost or the initial solar system investment cost. Using the generalized life cycle savings equation, a method is developed for calculating the solar heating system design which maximizes the life cycle savings. A similar method is developed for determining the set of economic conditions at which the optimal solar heating system design is just competitive with the conventional heating system. The results of these optimization methods can be presented in tabular or graphical form. The sensitivity of the economic evaluation and optimization calculations to uncertainties in constituent thermal and economic variables is also investigated.

# PREDICTING THE PERFORMANCE OF PASSIVE SOLAR-HEATED BUILDINGS. E. Mazria, M.S. Baker, and F.C. Wessling.

Sunworld, vol 2, no 2, May 1978, p. 42-49.

Early results on modeling direct-gain systems.

# DESIGN AND OPTIMISATION OF AN ABSORPTION REFRIGERATION SYSTEM OPERATED BY SOLAR ENERGY, by S. Alizadeh, F. Bahar and F. Geoola, Solar Energy, vol. 22, no. 2, 1979, p.149-155.

Abstract—A general theoretical study on design and optimisation of the water-lithium bromide and the ammonia-water absorption refrigeration cycles has been undertaken. The results of this study show that in general for fixed initial conditions and given system refrigeration capacity higher generator temperature causes higher cooling ratio with smaller heat exchange surfaces and consequently lower cost. A comparison of the two cycles also indicate that the water-lithium bromide system is simpler than the ammonia-water system and operates at a higher cooling ratio and smaller heat exchange surfaces for the same conditions.

Mechanical Engineering, v.101, no.1.

Jan. 1979

# SOLAR-ELECTRIC ENERGY. (Special Issue).

## 25 THE SOLAR-ELECTRIC HEATING AND COOLING EXPERIMENT

EPRI experiments, now under way, are attempting to identify the best solar systems for utilities and their customers by carefully considering what impact the different systems will have on utility operations and customer costs.

## United States. Dept. of Energy. Division of Solar Applications.

Solar heating and cooling demonstration : project summaries / U.S. Dept. of Energy, Assistant Secretary for Conservation and Solar Applications, Division of Solar Applications. — Washington : The Dept. : for sale by the Supt. of Docs., U.S. Govt. Print. Off., 1978.

viii, 182, 40, (40) p. : ill. ; 21 x 27 cm.

"DOE/CS-0009."

"UC-59A."

"UC-59."

1. Solar heating. 2. Solar air conditioning. 3. Solar houses. I. Title.

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78-602636

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**NSO-10604\*** University of Western Kentucky, Bowling Green  
**MSFC SOLAR HEATING AND COOLING HIGH SPEED  
PERFORMANCE (HISPER) CODE VALIDATION Final  
Report**

Henry M. Healey 12 Oct. 1979 15 p  
(Contract NAS8-33387)

(NASA-CR-181323) Avail: NTIS HC A02/MF A01 CSDL  
10A

The status of the Solar Heating and Cooling Project is reported.  
Modifications to the HISPER program are outlined, and recom-  
mendations concerning the validation study of HISPER are  
included. FOS

**NSO-10660\*** Pennsylvania Univ., Philadelphia. Dept. of  
Mechanical Engineering and Applied Mechanics.  
**OPTIMAL INSULATION OF PIPES AND TANKS FOR SOLAR  
HEATING SYSTEMS**

Gerard F. Jones and N. Lior Feb. 1979 75 p refs  
(Contract EM-78-C-04-5319)

(ALO-5319-2) Avail: NTIS HC A04/MF A01

A compact and time effective insulation design procedure  
for solar heating system piping and water-filled thermal storage  
tanks was developed. Recognizing the particular sensitivity of  
solar systems to cost, the economic aspect of the problem is  
treated by a comprehensive present-value life-cycle cost analysis.  
In the development of the method, a numerical sensitivity analysis  
was performed to determine the relative effects of all relevant  
independent variables (within their pertinent ranges) on piping  
and tank heat transfer coefficient values. DOE

### **TEST RESULTS ON LOW-COST THOMASON SOLAR HEATING SYSTEM AVAILABLE.**

Energy Engineering--Journal of the Association  
on Energy Engineers. vol 76, no 6, October/  
November 1979. p. 30-34.

### **CONTROLLER FOR A SOLAR HEATING SYSTEM WITH AN ELECTRICAL BACKUP. Adel H. Eltimsahy and Emilio A. Santos, Jr.**

Simulation, vol 33, no 2, August 1979.  
p.37-48.

This paper describes the mathematical modeling and  
optimization of a solar heating system that stores  
reserve energy from the electric power network. The  
paper focuses on the design of a controller which  
minimizes use of electric energy, uses that energy  
at times when its cost is low, and maximizes human  
comfort.

The mathematical model has identifiable state vari-  
ables, control input variables, disturbance input  
variables, and system parameters. The state vari-  
ables are temperatures in the solar collector, in  
the first storage tank, in the second storage tank,  
and in the room and walls. Electric power input to  
the heating coils, heat pump, and circulating pump  
form the control input vector. Ambient temperatures  
and solar radiation are treated as uncontrollable  
input variables.

The objectives of the optimization scheme are  
(1) maximizing the use of solar energy, (2) mini-  
mizing the cost of electricity, and (3) maximizing  
human comfort. These are combined into an overall  
system performance index. A suboptimal feedback con-  
troller based on this index uses an extension of  
Pearson's method; it involves (1) linearizing the  
system about an equilibrium point which shifts with  
time, (2) employing on-line computer control of the  
linearized system, and (3) changing the control  
strategy frequently.

Results of computer simulations show that the formu-  
lated controller acceptably achieved the design  
objectives.

**PUMPS FOR SOLAR SYSTEMS**, by Douglas Bingler.  
Solar Heating & Cooling, vol. 4, no. 3, April 1979,  
p.27-29.

Among the many types of solar systems that are presently being installed, there exist specific and individual system design and application parameters that must be considered for proper pump selection. The construction and performance of the pumps to be selected must satisfy the system design to assure optimal efficiency and dependability of the system. Specific pump information pertaining to the materials of construction, pumping capacities, power consumption, and recommended systems applications should be obtained for each system to be considered. By relying upon the expertise that exists among the many pump manufacturers, information can be provided to assist in the pump selection.

#### **COLLECTOR AND STORAGE EFFICIENCIES IN SOLAR HEATING SYSTEMS**

K. G. T. Holland, J. W. Chinneck and M. Chandrashekar

Solar Energy, vol. 23, no. 6, 1979, pp. 471-478.

**Abstract**—A general definition of the effective efficiency of solar collector operating in a solar energy system is presented which gives a fair method of comparison of different collectors operating in that particular application. Based on comparison between the area required for the actual collector and that of a perfect collector—both giving the same fraction solar—the definition permits the definition of the effective average value of the collector input parameter,  $P = (T_f - T_a)/S$ . The concept of the perfect collector also leads to a fair definition for the efficiency of the storage component in a solar heating system. These parameters are evaluated for the special case of residential space heating and service hot water systems of the standardized f-chart type operating in a number of Canadian cities. Simple methods for collector comparisons result from the study and indications are that a simple solar system design method will follow.

#### **CALCULATION OF CLIMATIC SOLAR HEATING PERFORMANCE**

Robert H. Bushnell

Solar Energy, vol. 23, no. 4, 1979, pp. 321-325.

**Abstract**—A climatic design method is presented which uses the long-term outdoor temperature distribution as well as utilizability of irradiation to find the solar fraction for building heat. The method considers a solar heater to be able, on the average, to supply all the heat needed by a building down to a cut-in temperature determined by the average amount of solar heat collected and the heat loss coefficient of the building. The amount of auxiliary heat needed is calculated from the kelvin day value below this cut-in temperature. The method permits the use of temperature distributions obtained from long records so that extremes can be represented. This allows calculations to be made near 100% solar heat. Any thermostat setting can be used. Several heat sources can be used. Examples are given.

#### **ECONOMIC FEASIBILITY OF SOLAR WATER-AND SPACE HEATING.**

R.H. Bezdek, et al.

Science, v.203, Mar.1979, p.1214-1220.

**Summary.** The economic feasibility in 1977 and 1978 of solar water and combined water and space heating is analyzed for single-family detached residences and multi-family apartment buildings in four representative U.S. cities: Boston, Massachusetts; Washington, D.C.; Grand Junction, Colorado; and Los Angeles, California. Three economic decision criteria are utilized: payback period, years to recovery of down payment, and years to net positive cash flow. The cost competitiveness of the solar systems compared to heating systems based on electricity, fuel oil, and natural gas is then discussed for each city, and the impact of the federal tax credit for solar energy systems is assessed. It is found that even without federal incentives some solar water and space heating systems are competitive. Enactment of the solar tax credit, however, greatly enhances their competitiveness. The implications of these findings for government tax and energy pricing policies are discussed.

**N80-14545#** Midwest Research Inst., Golden, Colo.

#### **COMMERCIALIZING SOLAR ARCHITECTURE**

Gregory Franta Mar. 1979 38 p refs Presented at SERI Architectural Planning Seminar, Golden, Colo., 10 Jul. 1978

(Contract EG-77-C-01-4042)

(SERI/TP-82-113; CONF-780792)

Avail: NTIS

HC A03/MF A01

Barriers to solar technology commercialization through architecture are considered. Attitudes of architects, their clients, government officials, and design/construction professionals are discussed along with technical issues related to the environment, building design and construction, operation, and maintenance. Performance evaluation of solar heating and cooling of buildings (SHACOB) and the general lack of technical awareness by architects regarding non-SHACOB technologies (wind, biomass, process heat, and photovoltaic cells) are included. Institutional issues related to law and government and the solar infrastructure are identified as important. Suggestions related to information, development, acquisition, and dissemination, education and training, demonstrations and design competitions, and other actions aimed at integration of solar technology into the total energy-conscious design process are given.

J.M.S.

**N80-14575#** General Accounting Office, Washington, D. C. Energy and Minerals Div.

#### **COMMERCIALIZING SOLAR HEATING: A NATIONAL STRATEGY NEEDED Report to the Congress**

20 Jul. 1979 86 p refs

(PB-297882/3; EMD-79-19) Avail: NTIS HC A05/MF A01

CSC 13A

The adequacy of the Nation's efforts to commercialize solar heating systems is discussed. Constraints facing the use of solar heating systems, the effectiveness of ongoing efforts to overcome these constraints, and the potential effectiveness of the National Energy Act in encouraging the use of solar heating systems are covered.

GRA

**Solar Heating System Final Design Package.**

Contemporary Systems, Inc., May 79, 70p

DOE/NASA/CR-161228 PC \$7.00/MF \$3.50

Contemporary Systems has taken its Series V Solar Heating System and developed it to a degree acceptable by local codes and regulatory agencies. The system is composed of the Series V warm air collector, the LCU-110 logic control unit and the USU-A universal switching and transport unit. The collector was originally conceived and designed as an integrated roof/wall system and provides a dual function in the structure. The collector serves both as a solar energy conversion system and as a structural weather resistant skin. The collector can be fabricated in any length from 12 to 24 feet. This provides maximum flexibility in design and installation. The LCU-110 control unit provides totally automatic control over the operation of the system. It receives input data from sensor probes in collectors, storage and living space. The logic is designed so as to make maximum use of solar energy and minimize use of conventional energy. The USU-A transport and switching unit is a high-efficiency air-handling system equipped with gear motor valves that respond to outputs from the control system. The fan is designed for maximum durability and efficiency in operation, and has permanently lubricated ball bearings and excellent air-handling efficiency.

**N80-17570#** Battelle Pacific Northwest Labs., Richland, Wash  
**SOME POTENTIAL MATERIAL SUPPLY CONSTRAINTS IN SOLAR SYSTEMS FOR HEATING AND COOLING OF BUILDINGS AND PROCESS HEAT. A PRELIMINARY SCREENING TO IDENTIFY CRITICAL MATERIALS**  
R. L. Watts, W. E. Gurwell, T. A. Nelson, and S. A. Smith: Jun. 1979 137 p. refs  
(Contract EY-76-C-06-1830)  
(PNL-2972) Avail NTIS HC A07/MF A01

Nine solar heating and cooling of buildings designs and three agricultural and industrial process heat designs were studied to identify potential future material constraints to their large scale installation and use. The systems were screened and found to be free of serious future material constraints. The screening was carried out for each individual system design assuming 500 million sq m of collector area installed by the year 2000. Also, two mixed designed scenarios, containing equal portions of each system design, were screened. Three materials were identified that could possibly restrain the deployment of solar systems in the specific scenarios investigated. They are iron and steel, soda lime glass and polyvinyl fluoride. All three of these materials are bulk materials. No raw material supply constraints were found DOE

Energy, v.4, no.5

Oct.  
1979

**RENEWABLE ENERGY PROSPECTS. (Special Issue).**  
**(Proceedings of a Conference on Non-Fossil Fuel and Non-Nuclear Fuel Energy Strategies.**  
**Held in Honolulu, Hawaii, Jan.9-12,1979.**  
**Sponsored by the United Nations University at Tokyo, Japan). Wilfrid Bach, et al, eds.**

Puri, V.: Status and prospects of local solar heating and cooling systems .... 769

**Abstract** In this paper, a state-of-the-art of solar heating and cooling systems is presented. Solar air heaters and different types of solar water collectors are discussed in detail. Storage systems including water, rocks, and heat-of-fusion salts are described as are space heating systems employing solar air heaters, in conjunction with rock or heat-of-fusion salt storage, and the use of water collectors plus hot water storage for space heating and domestic hot water. An indication of the commercialization of various space-heating systems and broad economic projections are presented. The three major solar cooling methods - absorption cooling, solar mechanical systems, and those involving humidification-dehumidification cycles - are also discussed in detail. Finally, an overview of solar heating and cooling activities in Kuwait is also given.

**ESTIMATION OF SECTOR SALES AND EMPLOYMENT CHANGES ASSOCIATED WITH SOLAR SPACE AND WATER HEATING DEVELOPMENT, by H. Craig Petersen, Solar Energy, vol. 22, no. 2, 1979, p.175-183.**

**Abstract**—There is little available information on sector-specific sales and employment impacts of a large-scale solar space and water heating industry. This study identifies those sectors of the economy which would be most affected by increased solar utilization and estimates the magnitude of the changes. The basic methodology involves augmenting an existing Input/Output table to include sectors reflecting solar technology. Data required to augment the matrix were obtained from questionnaires returned by existing firms involved in collector manufacture or solar space and water heating system sales. The augmented I/O matrix is inverted to generate a direct and indirect requirements matrix. The elements of this matrix estimate the changes in total sector output resulting from changes in final demand of other sectors. Estimates of final demand for solar heating systems by 1985 and projections of annual energy savings associated with solar installations to that time were obtained from existing studies. Using the computed direct and indirect requirements matrix and the assumed changes in the composition of final demand, estimates of changes in sales and employment were made for 131 sectors of the U.S. economy. It was determined that the sectors most affected by solar development will be those involved in electricity generation and the mining, refining, and fabrication of metals, especially copper. The proportionate changes in industry sales and employment are not expected to be very great. Only copper rolling and drawing is changed by as much as two percent. This finding suggests that the U.S. economy can accommodate an expanded use of solar heating without undue stress.

**A79-50537** Economic evaluation and optimization of solar heating systems. M. J. Brandemuehl and W. A. Beckman (Wisconsin, University, Madison, Wis.). *Solar Energy*, vol. 23, no. 1, 1979, p. 1-10. 7 refs.

A procedure is developed for assessing the economic viability of a solar heating system in terms of the life cycle savings of a solar heating system over a conventional heating system. The life cycle savings is expressed in a generalized form by introducing two economic parameters, P1 and P2, which relate all life cycle cost considerations for the first year fuel cost or the initial solar system investment cost. Using the generalized life cycle savings equation, a method is developed for calculating the solar heating system design which maximizes the life cycle savings. A similar method is developed for determining the set of economic conditions at which the optimal solar heating system design is just competitive with the conventional heating system. The results of these optimization methods can be presented in tabular or graphical form. The sensitivity of the economic evaluation and optimization calculations to uncertainties in constituent thermal and economic variables is investigated. (Author)

**A80-18583** // Preliminary analysis of a total solar heating system. C. B. Winn, P. Burns, E. Trigg (Colorado State University, Fort Collins, Colo.), and J. Leflar (SEEC, Inc., Fort Collins, Colo.). *American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Dec. 2-7, 1979, Paper 79-WA/Sol 40*. 7 p. Members, \$1.50; nonmembers, \$3.00.

The thermal and economic performances of long-term storage solar systems have been studied by use of a computer simulation developed at Colorado State University. The systems have been analyzed for Madison, Wisconsin and Boulder-Denver, Colorado. The effects of long-term storage size, long-term storage insulation and collector tilt angle have been detailed. Economic analyses indicate savings vs. long-term storage volume for various values of rock box insulation. Also, some interesting heat transfer effects are presented. Results indicate that long-term storage systems perform well where the annual heat load is high and the values of winter insolation are low. Also, relatively small (142 cu m) storage volumes performed most economically. (Author)

**54427** (DOE/ERD-0018) Environmental Readiness Document: solar heating and cooling of buildings. (Department of Energy, Washington, DC (USA)). Sep 1979. 28p. Dep. NTIS, PC A03/MF A01.

The technology is described briefly and the environmental concerns associated with it are reviewed. A status report on the technical and environmental R and D programs is provided and the relationship between the technical and environmental R and D is displayed in a milestone chart in terms of desirable timing. The likelihood of adverse findings concerning the environmental acceptability of the technology, the problems and uncertainties stemming from current or anticipated environmental regulation, and the potential costs of environmental controls are examined. An assessment is offered of the existing or potential barriers to commercialization. A tabulation of environmental concerns is presented with the research needed to resolve the concerns and its estimated cost. (MHR)

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**Intersociety Energy Conversion Engineering Conference, 14th, Boston, 1979.**

Proceedings of the 14th Intersociety Energy Conversion Engineering Conference, Boston, Massachusetts, August 5-10, 1979. -- Washington, D. C. : American Chemical Society, c1979.

**799056**  
Development of a Solar Desiccant Dehumidifier - Part II, D. Gidaspow, Z. Lavan, V.C. Mei and H. Ghezeayagh ..... 264

**799057**  
Sensible and Latent Comfort Cooling Requirements of Conventional and Passively Cooled Residences in American Climates, G. Clark and C. Allen ..... 269

**799058**  
The Desiccant/Rock Bed Method of Solar Cooling with Air Collectors, D.B. Meredith and P.J. Wilbur ..... 274

**799059**  
Solar Heated Absorption Refrigeration System, R. Hatami ..... 278

**Solar Energy System Installed at Mount Rushmore National Visitor Center in Keystone, South Dakota. South Dakota School of Mines and Technology, Jun 79, 42p**

**DOE/NASA/CR-161238 PC \$6.00/MF \$3.50**

Information is provided on the system description, the design, and installation of the solar energy system installed at the Mount Rushmore Visitor Center. The system is designed to furnish about 45 percent of the heating for the total facility and about 53 percent partial cooling for the 2000 square-foot observatory. Such items as Acceptance Test Data, a complete set of as-build drawings, system performance data, problems, pictures, and other pertinent materials are included.

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**N80-17569/** Midwest Research Inst., Golden, Colo.  
**OVERVIEW OF DEVELOPING PROGRAMS IN SOLAR  
 DESICCANT COOLING FOR RESIDENTIAL BUILDINGS**  
 1979 18 p Presented at the ASHRAE Soc. Meeting, Detroit,  
 24 Jun 1979  
 (Contract EG-77-C-01-4042)  
 (SERI/TP-34-187; CONF-790678-3) Avail: NTIS  
 HC A02/MF A01

Open cycle adsorption and absorption systems are examined.  
 The different dehumidifier bed configurations are the distinguishing  
 features of these systems. The basic operating principles of each  
 dehumidifier concept are explained along with some discussion  
 of their comparative features. Performance predictions devel-  
 oped by SERI for a solar desiccant solar system employing an  
 axial flow desiccant wheel dehumidifier are presented. In terms  
 of life cycle cost and displaced fossil fuel energy, the results  
 indicate that it should be beneficial to use solar desiccant coolers  
 in residential applications. DOE

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**International Solar Energy Society. UK  
 Section.**

The passive collection of solar energy in  
 buildings : conference (C19) at the Royal  
 Institution, April 1979. -- London : UK-  
 ISES, [1979?]

91 p. : ill.

Cover title.

Bibliography: p. 87-91.

1. Solar heating--Congresses. 2. Solar  
 houses-- Congresses. I. Title.

**DESIGN OF A COMBINED SOLAR COLLECTION/ABSORBER/  
 DESORBER FOR A SOLID-ABSORPTION REFRIGERATING  
 SYSTEM.** P. Verste-Schmidt and P. Bechtold.  
 Nielsen, Technical University of Denmark.  
 (Presented at AIAA-ASME Thermophysics & Heat  
 Transfer Conf., Palo Alto, CA, May 24-25, 1978).  
 1978. 8p.

American Society of Mechanical  
 Engineers  
 American Institute of Aeronautics  
 and Astronautics  
 Conference on Thermophysics and  
 Heat Transfer

CONF  
 78-NT-35

MAY 24-25,  
 1978

abstract at top of next column

An experimental investigation of absorption and desorption of ammonia in calcium chloride and strontium chloride was performed under conditions corresponding to those existing in a solar-powered refrigerated system. A simple mathematical model was developed for extension and interpretation of the experimental data. It has been shown that the necessary collector temperatures are within the working range of flat-plate solar collectors, and reasonable design parameters for a combined solar collector/absorber/desorber have been determined. Preliminary tests with a small demonstration plant have substantiated the experimental and theoretical findings.

**A78-49948** Design of solar heating and cooling systems for  
 nonresidential buildings in the east north central region of the United  
 States. R. K. Newman (Dayton, University, Dayton, Ohio). In:  
 NAECON '78; Proceedings of the National Aerospace and Electron-  
 ics Conference, Dayton, Ohio, May 16-18, 1978. Volume 2.  
 (A78-49851 22-04) New York, Institute of Electrical and Electronics  
 Engineers, Inc., 1978, p. 862-867.

Descriptions of various solar heating and cooling projects in an  
 area in which 60 percent of the U.S. population lives are given with  
 emphasis on the Troy-Miami County Library system which was put  
 in operation this past winter. Instrumentation and control strategies  
 for the various modes of operation are discussed for this system, the  
 Columbus Technical Institute Phase V, and the Stark County Library  
 buildings which will provide both solar heating and cooling. The use  
 of solar energy to provide a large quantity of domestic hot water,  
 swimming pool heat, and assistance to heat pumps is discussed with  
 respect to the Deer Creek Lodge solar project. Brief descriptions of  
 solar heating systems for a Dayton Fire Station and a Mound  
 Laboratories building are also given. (Author)

**N78-31838/** National Aeronautics and Space Administration.  
 Goddard Space Flight Center, Greenbelt, Md.  
**GREENBELT COMMUNITY PROJECT: SOLAR ENERGY  
 RETROFIT FOR A MULTI-FAMILY DWELLING**  
 E. W. Hymowitz, R. J. Hannemann (Hannemann Eng. Serv., Upper  
 Marlboro, Md.), L. L. Millman, and J. E. Pownell Jun. 1978  
 133 p refs  
 (NASA-TM-79612) Avail: NTIS HC A07/MF A01 CSCL 10A

A cooperative project was initiated between Goddard Space  
 Flight Center and the nearby community of Greenbelt, Maryland.  
 The purpose was to design, install and operate an experimental  
 solar heating system on a group of four tandem town houses.  
 The system was successfully developed and is operating. A  
 description is given of the design, installation, system operation  
 and performance as well as the important considerations for  
 judging the economic feasibility of solar heating systems. LS.

# ASYMPTOTIC BEHAVIOUR AS A GUIDE TO THE LONG TERM PERFORMANCE OF SOLAR WATER HEATING SYSTEMS,

by B. J. Brinkworth

Solar Energy, vol. 21, no. 3, 1978, p. 171-175

**Abstract**—It is shown that good predictions of the long-term performance of solar water heating systems may be obtained from the asymptotic behaviour as the storage mass becomes indefinitely large. This can be evaluated with very little labour, enabling quick estimates to be made of optimum design parameters, and narrowing the range of conditions which need to be covered by more accurate but more costly methods.

**N79-31803/** AIA Research Corp., Washington, D. C.  
**PASSIVE SOLAR DESIGN: A SURVEY OF MONITORED BUILDINGS**

Oct 1978 360 p refs  
(Contract EG-77-C-01-4113)

(HCP/CS-4113-2) Avail: NTIS HC A16/MF A01

This survey consists of collected articles reporting the thermal performance of buildings using passive solar techniques, plus a matrix tabulating the information contained in the reports, and a verbal summary of the results. Most of the articles were published previously; additional information was gathered from owners and designers and is attached as an addendum to the articles.

DOE

**A79-13857 #** Passive solar heating and cooling. R. Naismith (Atlantic Research Corp., Alexandria, Va.). *American Institute of Aeronautics and Astronautics and Arizona Solar Energy Research Commission, Conference on Solar Energy Technology Status, Phoenix, Ariz., Nov. 27-29, 1978, AIAA Paper 78-1756*, 5 p. 5 refs.

The paper discusses the passive solar energy concept which uses the building itself as a collector. Three types of gain may be used: direct gain where the energy is stored in a thermal mass, indirect gain where the solar energy goes directly into storage and is then released into the living space, and isolated gain where the solar energy is naturally transferred from a separate part of the structure into the living space. Various applications of passive solar energy systems are described including a Benedictine Monastery in New Mexico, an airport terminal in Aspen, Colorado, and a restaurant in Albuquerque, New Mexico.

S.C.S.

## SOLAR HOT WATER -- THE EASY WAY!

D. Khanh.

Alternative Sources of Energy, no. 32, June 1978, p. 11-13.

Dinh Khanh designed this water heater to be a simple unit, in terms of both construction and maintenance.

## PASSIVE SOLAR - A CONTROLLED EXPERIMENT IN HOME HEATING

Arthur Fisher

Popular Science, vol. 212, no. 4, April 1978  
p76-79

**N79-31804/** AIA Research Corp., Washington, D. C.  
**PASSIVE SOLAR DESIGN: AN EXTENSIVE BIBLIOGRAPHY**

Dec. 1978 210 p  
(Contract EG-77-C-01-4113)

(HCP/CS 4113-3) Avail: NTIS HC A10/MF A01

Approximately 2445 citations on passive solar design are presented. Materials included in major data banks as of January, 1978 are included along with the proceedings of the Second National Passive Conference. Subject areas include agriculture, costs, design concepts, greenhouses, energy storage, and evaporation.

DOE

**A78-48814** Solar wall performance. J. Cash (College of Technology, Dublin, Ireland). *International Journal of Energy Research*, vol. 2, July-Sept. 1978, p. 229-245. 9 refs.

The thermal behavior of small solar walls consisting of an opaque inner leaf and a transparent outer leaf is characterized. The data support application of one-dimensional heat transfer theory which describes thermal behavior in terms of the wall thermal transmittance, a solar gain factor, and an environmental temperature. Solar radiation measurements, environmental temperatures, and determinations of the average solar gain and the instantaneous solar gains are reported. Limitations of data obtained from small test units and modifications of solar wall design are considered.

M.L.

**N79-31818/** Department of Energy, Washington, D. C. Office of Conservation and Solar Applications.  
**PASSIVE SOLAR ENERGY PLANNING AID KIT FOR SOLAR ENERGY SYSTEMS ENGINEERS**

1978 106 p refs Presented at the 2d Natl. Passive Solar Conf. Philadelphia, 16 Mar. 1978  
(Contract EM-78-C-01-4228)

(CONF-780337-P3) Avail: NTIS HC A06/MF A01

Separate abstracts were prepared for eleven of the included papers. The remaining two papers appeared previously in ERA.  
Author (DOE)

SEE! PASSIVELY HEATED UNDERGROUND HOUSES CAN BE BEAUTIFUL TOO!

The Mother Earth News, no. 51, May/June 1978,  
p. 101-103.

## PASSIVE SOLAR HEATING AND COOLING SYSTEMS. J.I. Yellott.

ASHRAE J., v.20, no.1, Jan.1978, p.60-67.

*Passive solar systems use the sun's radiation for heating and natural processes (connection, radiation and evaporation) for cooling. Three passive heating systems and one natural cooling system have evolved, had extensive testing and are in use in a rapidly growing number of residences in the U.S. and abroad. This paper was presented at a Symposium, Passive Systems for Solar Utilization, during ASHRAE's 1977 Annual Meeting in Halifax, N.S., Canada.*

**A79-31422** Measured and predicted performance of solar domestic water heaters. J. M. Bell and J. T. Strack (Ontario Hydro, Research Div., Toronto, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 15 p. 7 refs.

Solar water heating offers good potential for the conservation of electricity in Ontario, since about half of existing water heaters in this province are electric. To examine the present state-of-the-art of commercially available solar water heater systems, Ontario Hydro has purchased and tested several systems. The paper describes the systems purchased, the test program and the results. The instrumentation package including special instrumentation developed for the tests is discussed. An outline is given of a simple analytical technique which was adapted to permit accurate prediction of the annual performance of any solar water heater system on a month by month basis. (Author)

**A79-31435** Solar heating and ventilation using the modified Trombe wall system (Chauffage et ventilation solaire par le système mur Trombe modifié). E. Bilgen and M. Chaaban (Ecole Polytechnique, Montreal, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 7 p. In French.

A description is presented of the first stages of a theoretical and experimental investigation of the modified Trombe wall. The wall in its original form had first been considered by Trombe (1974). The Trombe wall as a solar energy collector has great thermal inertia. It performs a number of functions related to the collection of solar energy, the passing on of a part of the energy by means of a thermal circulation process, and the accumulation of the remainder of the energy in its own mass. A major problem of this system is the great loss of energy which takes place during the night. The investigation is concerned with the possibility to eliminate this drawback with the aid of an approach involving a separation of the energy collection and energy storage functions. G.R.

**NSO 10659** Committee on Science and Technology (U. S. House)

### PASSIVE SOLAR ENERGY PROGRAMS AND PLANS

Washington GPO 1978 432 p Hearing before the Subcomm. on Advanced Energy Technologies and Energy Conservation Res., Development and Demonstration of the Comm. on Sci. and Technol., 95th Congr., 2d Sess., 19 Sep. 1978 (GPO-38-211) Avail: Subcomm on Advanced Energy Technologies and Energy Conservation Res., Development and Demonstration

Testimony delivered and statements received regarding passive solar energy systems development under the Solar Heating and Cooling Demonstration Act (PL 93-409) are presented. Basic approaches are described as well as the use of specific heat absorbing materials in building construction and the use of windows and baffles to control the amount of sunlight received. Additional research needs are examined. Market demand, technology transfer, and technology utilization are also considered. A.R.H.

**N78-30774** TRW, Inc., McLean, Va. Energy Systems Planning Div.

### COST AND PERFORMANCE EVALUATION OF PASSIVE SOLAR SYSTEMS

Nov. 1978 68 p refs

(Contract W-31-109-eng-38)

(ANL/EES-TM-34) Avail: NTIS HC A04/MF A01

This study was undertaken to produce a detailed methodology for designing optimal passive solar systems for single family residences. Earlier work showed that passive solar systems were economically more favorable than conventional HVAC systems. The earlier results were refined and a broader range of passive solar system configurations were examined in a wider variety of climate and insolation conditions. This study was divided into the following four major tasks: methodology development, refinement of cost and performance data, development of computer program, and analysis of thermal/storage walls. DOE

**54446** Passive solar heating of buildings. Balcomb, J.D.; Hedstrom, J.C.; McFarland, R.D. (Los Alamos Scientific Lab., NM). pp 123-155 of Energy from the sun. Chicago, IL; Institute of Gas Technology (1978).

From Symposium on energy from the sun, Chicago, IL, USA (3 Apr 1978).

Passive solar heating concepts - in which the thermal energy flow is by natural means - are described according to five general classifications: direct gain, thermal storage wall, solar greenhouses, roof ponds, and convective loops. Examples of each are discussed. Passive test rooms built at Los Alamos are described and results are presented. Mathematical simulation techniques based on thermal network analysis are given together with validation comparisons against test room data. Systems analysis results for 29 climates are presented showing that the concepts should have wide applicability for solar heating.

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**A79-14720** Passive solar design. B. N. Anderson and C. J. Michal (Total Environmental Action, Inc., Harrisville, N.H.). In: Annual review of energy. Volume 3. (A79-14718 03-44) Palo Alto, Calif., Annual Reviews, Inc., 1978, p. 57-100. 11 refs.

The use of the term 'passive' was introduced several years ago to describe those methods of employing solar energy that do not use mechanical power but instead use natural energy flows for the transfer of thermal energy into, out of, and through a building. Passive solar systems in the social context are examined and a description of the major passive systems is presented. These systems are related to the direct admission of sunlight into the space to be heated, the employment of convective loops utilizing an absorber surface remote from the building space to absorb incidental radiation, the use of thermal storage walls, attached greenhouses, a utilization of various forms of heat storage, and approaches of heat transfer control. Attention is given to domestic hot water heating, thermosiphoning air collectors, specific designs involving passive schemes, Trombe walls, solar roof ponds, and cost and energy data regarding thermosiphoning air panels. G.R.

**N79-32738#** New Mexico Energy Inst., Albuquerque.  
**THEORETICAL ANALYSIS OF A PASSIVE HEAT PIPE HEATING AND COOL SYSTEM**  
K. T. Feldman Dec. 1978 46 p refs Sponsored in part by N. Mex. Energy and Minerals Dept., Santa Fe (PB-296066/4; NMEI-23/SA) Avail: NTIS HC A03/MF A01 CSCI 13A

A totally new concept which combines both a heat pipe and a flat plate solar collector for daytime solar water heating and nighttime water cooling was studied theoretically. Since the heat pipe is a passive heat transfer device, the entire system requires no pumps or auxiliary power for its operation. This makes the system reliable and should require very little maintenance. This system with a collector area of 400 sq ft can meet both winter space heating and summer space cooling requirements. For a typical winter day it can provide about 8000 lbs/day of hot water at 140 F or about 530,000 Btu/day. For a summer day it can provide about 4000 lbs/day of chilled water at 45 F or about 100,000 Btu/day for space cooling. G.R.A.

**A78-23425**

**PASSIVE SOLAR HEATING AND COOLING SYSTEMS.**

J.I. Yellott.

ASHRAE Trans., v.83, pt.2, 1977, p.429-445.

The variety of passive solar heating and cooling systems already in use is so great that definitive classification is extremely difficult. However, a relatively simple system evolved by the Solar Energy Research Group in the College of Architecture, Arizona State University, seems to cover most of the passive structures now in use. The names attached to these buildings are generally those of their originators or their first users. Several of the systems are covered by U. S. or foreign patents, but most of them are in the public domain. There are three principal passive heating systems.

**Campbell, Stu.**

**Build your own solar water heater / Stu Campbell; with Douglas Taff; ill. by Robert Vogel. -- Charlotte, Vt. : Garden Way Pub., c1978.**

viii, 109 p. : ill. ; 28 cm.

Bibliography: p. 104.

Includes index.

ISBN 0-88266-129-9 : \$10.95. ISBN 0-88266-128-0 pbk. : \$7.95

**1. Solar heating. 2. Water heaters. I. Taff, Douglas, joint author. II. Title.**  
TH7413.C35 696+.6 77-28692

**A79-31442** Control system for solar hot water system. M. J. Lesperance, R. M. Tomita, and S. Cadieux (Atelier Solaire Enrg., Pointe Claire, Quebec, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 7 p.

Although the solar energy industry is relatively young, it has a certain maturity through the industries which service it. One of these industries is the process control industry. In order that the solar industry benefits from the experience acquired by the process control industry, it is essential to apply the accepted standard practices. The processes found in a solar energy heliothermal system are comparable in their simplest form to a heat exchange loop where the sun is the heat source. The variables to control include temperatures, flows, and pressures. The common practices in the process control industry are examined, taking into account the application of these practices to the solar energy industry and, particularly, to hot water heating systems using fixed flat plate collectors. G.R.

**PASSIVE COOLING SYSTEMS IN IRANIAN ARCHITECTURE**

Mehdi N. Bahadori

Scientific American

Vol.238 no. 2 Feb. 1978

p. 144-152

## Environmental Action Reprint Series

### NATURAL SOLAR ARCHITECTURE — A PASSIVE PRIMER, by David Wright, AIA

A guidebook for the architect, engineer, student, contractor, homeowner, or anyone who wants to know more about the passive approach to solar architecture. In passive solar design, the building itself collects, stores, and distributes the sun's energy, as opposed to active solar systems, which rely on solar collector panels and associated mechanical devices for space heating and cooling. In a smooth, easy-to-follow manner, such factors as the greenhouse effect, heat transfer, heat loss, heat gain, surface-to-volume ratio, and heat sink are explained and discussed. An early innovator and leading solar architect, David Wright has designed numerous passively heated solar structures throughout the country.

266 pages, paperbound (© 1978) ..... \$7.95

**A79-31437** Domestic water preheating using solar energy. V. M. Ireton (New Brunswick University, Fredericton, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 11 p.

This paper reports upon the experience gained from the operation and monitoring of a closed loop solar energy collection system to preheat domestic water. The system has operated continuously and reliably since it was commissioned in late March 1977. Data collection began on April 1, 1977 and has continued to date. The contribution by solar energy to the preheating of the domestic water has been much less than that predicted by an f-chart analysis of the system as installed. The disagreement between experience and the f-chart model seems to be principally because of poor heat exchanger effectiveness and reverse thermal stratification in the preheat tank. It may be that drain-back or drain-down systems would be more effective than closed loop collection systems.

(Author)

**N78-30783** Los Alamos Scientific Lab., N. Mex. **SIMPLE TECHNIQUE OF ESTIMATING THE PERFORMANCE OF PASSIVE SOLAR HEATING SYSTEMS** J. D. Balcomb and R. D. McFarland 1978 8 p refs Presented at the 1978 ISES Conf., Denver, Aug. 1978 (Contract W-7405-eng-36) (LA-UR-78-1571: Conf-780808-15) Avail: NTIS HC A02/MF A01

A method is presented for estimating the annual solar performance of a building using a passive thermal storage wall of the Trombe wall or water wall type with or without night insulation. Tables of performance parameters are given for 84 cities. The method is accurate to +3% as compared with hour-by-hour computer simulations. DOE

Solar Heating & Cooling, v.3, no.5, Oct.1978.

## APPLICATIONS

- |    |   |
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| 52 | CETA Workers Install Rhode Island System                        |
| 53 | Domestic Water System Designed for Mid-Atlantic Region          |
| 54 | Collectors Vertically Mounted in Domestic Hot Water Retrofit    |
| 56 | Trickle-Flow Collectors are Main Component of Simplified System |
| 57 | Impressions Restaurant Combines Active and Passive Systems      |

**N80-10645** Los Alamos Scientific Lab., N. Mex. **ECONOMIC PERFORMANCE OF PASSIVE SOLAR HEATING: A PRELIMINARY ANALYSIS** Fred Roach, Scott Noll (New Mexico Univ., Albuquerque), and Shaul Ben-David 1978 11 p refs Presented at AIAA/ASERC Conf. on Solar Energy, Phoenix, Arizona, 27-29 Nov 1978 (LA-UR-78-2861: Conf-781133) Avail: NTIS HC A02/MF A01

For the thermal storage wall two types of storage medium—masonry (Trombe) and water are examined. In addition, a night insulation option is included in the thermal storage wall concept, thus giving rise to four alternative passive designs. The economic performance of these alternative designs is evaluated on a state-by-state basis. The architectural design criteria, solar performance characteristics, and the incremental solar cost of each solar design are reviewed. Conventional energy costs are discussed as well as the optimal sizing/feasibility criterion employed in the economic performance analysis. Nationwide feasibility results are reviewed for each alternative design. In addition to contracting the solar systems themselves, the effects of two incentive proposals—the National Energy Act (NEA) income tax credits and low interest loans upon each design are examined. Major conclusions are summarized for each design. DOE

## PASSIVE SOLAR

Arthur Fisher

Popular Science, vol. 212, no. 4, April 1978, p. 76-79

How can you keep solar heating simple? Scientists compare three different approaches in a unique test

**Alternative Sources of Energy,  
no. 33.**

**Aug.  
1978**

**EARTH SHELTERED HOUSING. Special Edition.**

**PASSIVE SOLAR HEATING. Special Edition.**

**Special Underground Section**

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Northern Climate Underground Home by Jim Laukes. ....	6
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An Earth-Bermed House For Florida by Dinh Khanh. ....	14

**A79-31444** Passive solar heating - Results from two Saskatchewan residences. R. S. Dumont, R. W. Besant (Saskatchewan, University, Saskatoon, Canada), G. Jones (Botling and Associates, Ltd., Saskatoon, Canada), and R. Kyle (Aquitaine of Canada, Ltd., Rainbow Lake, Alberta, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 17 p. 13 refs.

A description is presented of two houses incorporating design principles of passive solar heating. The dwellings were completed in the winter of 1977-78, one located in Saskatoon and the second in Regina. Performance tests on the houses were conducted in the spring of 1978. Both of the dwellings were of a direct gain type, with southerly oriented windows and no vertical thermal mass such as a concrete wall behind the windows. The performance tests show that passive solar heating can contribute a large fraction of the heating requirements. For the Regina residence, the contribution of passive gains should amount to 44% of the heating requirement during the heating months. Thermal shutters can be of significant value in reducing both the heat loss from dwellings and in moderating the temperature falls at night in well insulated dwellings. G.R.

**N78-31838\*** Solar Engineering and Mfg. Co., Ft. Lauderdale Fla.

**DESIGN DATA BROCHURE: SOLAR HOT WATER SYSTEM**

Jul. 1978 21 p Prepared for DOE  
(Contract NAS8-32247)

(NASA-CR-150699) Avail: NTIS HC A02/MF A01 CSCL 10A

A design calculation is detailed for a single-family residence housing a family of four in a nonspecific geographical area. The solar water heater system is designed to provide 80 gallons of 140 F hot water per day. G.G.

**ALTERNATIVE SOURCES OF ENERGY, no. 34, Oct 1978.**

**Special Section: Solar Hot Water**

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Breadbox Designs .....	10
David Bainbridge and Jeff Reiss	

**A79-31438** Economic design of a solar domestic water heating system. G. K. Yuill (UNIES, Ltd., Winnipeg, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 9 p. Research supported by the National Research Council of Canada.

The described investigation had the objective to minimize the cost of a solar domestic water heating system designed to supply 50% of the energy required to heat the domestic hot water for a ten unit townhouse in Winnipeg. The townhouse will have a central mechanical equipment room where the solar energy equipment will be installed. The preheated water from the solar energy system will be fed into conventional gas fired domestic water heaters in the ten housing units. Aspects of computer program development for the optimization study are considered. The investigation showed that for a domestic water heating system, there is a physical optimum tank size. This is not true for space heating systems, for which system performance increases with tank size and the tank size is determined by an economic optimization. The cheapest of several single glazed collectors considered, was found to be the most cost effective. G.R.

**PASSIVE SOLAR CONFERENCE: ENTHUSIASM AND A GROWING EXPERIESE.**

Gary Kah

Solar Heating & Cooling, Vol. 3, No. 2, April 1978, p. 39-41

The challenge is to incorporate passive techniques into current building practices and to inform consumers of their economic advantages.

**A79-31420** **Performance of the Meadowvale solar home.**  
B. E. Sibbit, H. Jung, and D. Lorrimer (National Research Council, Div. of Building Research, Ottawa, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 10 p. 6 refs.  
Monitoring of the Meadowvale Solar Experiment in Mississauga,

Ontario, began in October 1976 and has continued to date. The paper presents a performance summary of monitoring results of the first two complete heating seasons of solar system operation. Data for the period from October 1976 through April 1978 show that the solar system provided 51% of the space heating requirement, 14% of the service-water heating requirement and that 54% of collected energy was lost from storage. The paper also contains brief descriptions of the solar system, the house and the monitoring system.  
(Author)

**A79-31417** **The Saskatchewan Conservation House - Some preliminary performance results.** R. W. Besant, R. S. Dumont, and G. Schoenau (Saskatchewan, University, Saskatoon, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 17 p. 5 refs. Research supported by the Saskatchewan Housing Corp., Department of Mineral Resources, and Saskatchewan Research Council.

The performance of the Saskatchewan Conservation House for the spring of 1978 is reported. This house was designed primarily as a demonstration to the public of the energy savings possible in residential construction. The Saskatchewan Conservation House is one of a small number of residences constructed which are designed for 100% space heating using active solar collection systems. The provided report includes a listing of the theoretical and measured heat loss characteristics of the house, the passive solar gain behavior of the house, and efficiencies for the solar collector panels. Estimates are made of the annual energy consumption of the house based on a normal occupancy pattern.  
G.R.

**THE SUN BLEST HOUSE**  
Bill and Wanda Colyer  
Alternative Sources of Energy  
Vol. no. 30 February 1978  
p. 4-7

The purpose of building the Sun Blest House was to provide a comfortable energy conservative home using only renewable energy sources - solar heat, primarily, and wood heat for back-up. The architectural design approach was to provide a southwest solar farm house. The objectives included building a home with small temperature extremes and con-

structed with readily available native materials using simple and conventional building techniques wherever possible.

Part I was published in the December '77 issue of ASE, no. 29.

**UNDERGROUND SOLAR HOUSE**, by V. Elaine Smay.  
Popular Science, vol. 213, no. 6, December 1978,  
p. 86.

Our solar-heated underground leisure home was designed by the award-winning architect, Alfredo De Vido. Many readers will remember the Sun Trap he designed for last November's PS and recognize some of the same features in this plan. But in most ways, our

underground house is unique. Its brick shell, curved for strength against the massive earth pressure, is shown nestled into a steep hillside. But on flatter terrain, the house could be built on the surface and bermed with earth after completion. The vaulted walls are of corbeled masonry, which should be within the skills of an experienced mason.

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**International Symposium-Workshop on Solar Energy, Cairo, 1978.**

**International Symposium-Workshop on Solar Energy : [symposium lectures], 15-22 June 1978, Cairo, Egypt / presented by Clean Energy Research Institute, University of Miami, Florida ; sponsored by National Science Foundation ; edited by T. Nejat Veziroglu, Homer W. Hsiao. -- [s.l.:s.n..**

**INTEGRATED SOLAR BUILDING SYSTEM** *P.177*

A. Bowen, University of Miami, Coral Gables, Florida, U.S.A.

*P.215*  
**APPLICATION OF SOLAR COOLING FOR A SCHOOL BUILDING IN SUBTROPICS**  
A. J. Parker, Mueller Associates, Baltimore, Maryland, U.S.A.

**Problems Encountered by Lending Institutions and Appraisers with Respect to Solar-Equipped Buildings. Final Report of Innovative Research Program Subtask, December 1977-September 1978.**

Colorado State Univ., Oct 78, 21p

COO-4546-11 PC \$4.00/MF \$3.50

It was proposed to assess the overall attitudes of Colorado lending institutions towards making loans for construction of solar equipped buildings. A second objective was to identify what problems appraisers have in placing values on solar equipped buildings. Information needed was obtained through mail surveys of 132 banks and 103 appraisers responding.



**A79-31453 First year performance data and lessons**

learned in the NRC 14 house solar demonstration program. W. E. Carscallen and B. E. Sibbitt (National Research Council, Div. of Building Research, Ottawa, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 2. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 14 p.

**N80-16599/ Utah Univ., Salt Lake City.  
CONFERENCE ON PERFORMANCE MONITORING TECHNIQUES FOR EVALUATION OF SOLAR HEATING AND COOLING SYSTEMS**

1978 353 p refs Conf held in Washington, D.C. 3 Apr 1978

(Contract EG-77-S-04-4094)

(CONF-780432) Avail: NTIS HC A16/MF A01

A general review of solar energy monitoring systems, their relationship to data users and their needs, and a methodology for developing instrumentation systems and performance evaluation techniques based on a systematic procedure for addressing the actual needs of the data user are provided. DOE (3) foam lift/hydraulic turbine; and (4) mist lift/hydraulic turbine. A preliminary assessment of achievable performance is made in addition to a description of the subsystem performance objectives which would support the achievement of the full potential inherent in these concepts. The results and conclusions include a description of the research objectives, achievement of which make open cycle OTEC a viable alternative as a national energy source.

DOE

**N79-32887/ Aerospace Corp., El Segundo, Calif.  
SOLAR HEATING AND COOLING OF BUILDINGS  
(SHACOB): REQUIREMENTS DEFINITION AND IMPACT ANALYSIS**

C. K. Cretcher and W. C. Melton Jun. 1978 82 p refs  
Sponsored by Elec. Power Res. Inst.

(EPRI Proj. 553)

(EPRI-ER-808-SY) Avail: NTIS HC A05/MF A01

The economic impact of various (SHACOB) design concepts on the electric utilities and their customers was assessed along with system requirements for optimizing this impact. Weather and insulation inputs for simulations were established for locations across the United States. Reference buildings and their thermal properties were defined, and detailed internal and external load models generated to characterize building thermal performance. Both solar and conventional systems, including load management systems featuring nighttime thermal storage were simulated. The systems analyzed in detail were direct solar systems with and without a load management capability, solar assisted heat pumps, and customer load management systems. These systems were evaluated with respect to conventional resistive and heat pump systems. Projections for buildings and types of heating system installations in those buildings were developed by eight participating utilities for their own service areas.

DOE

**A79-31434 Solar energy retrofit system for an older-type building - The Williamstown Museum project.** G. McKel and E. Broomhall (John Abbott College, Sainte Anne de Bellevue, Quebec, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 13 p. 20 refs. National Research Council Contract No. 077-9.

The rationale for the retrofit of Williamstown Museum with a solar heating system was to provide the community with a high profile, easily accessible prototype which would engender interest and provide a design basis for solar systems in extant buildings. The space heat load base was designed on a 50 F indoor temperature and -20 F outdoor temperature to give a design temperature difference of 70 F. A flat plate, back pass modular solar collector was designed, measuring 3 x 16 ft. Though 16 collector modules were needed to provide 60% of the building's thermal demand another 5 modules were added to help offset losses in the long duct runs and the change from corrugated to flat absorber plate. The collectors were hoisted to the roof by a crane.

G.R.

**A79-31421 Off-peak electrical backup experience in the Meadowvale Solar Experiment.** J. M. Bell (Ontario Hydro, Toronto, Canada) and D. Lorrman. In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 11 p.

When electricity is used for backup heating in solar heated houses, the maximum electric demand usually occurs when winter-peak utilities are least capable of supplying it. An off-peak electric backup system was designed and incorporated into the existing storage system of the Meadowvale Solar Experiment to investigate the benefits and problems associated with this mode of operation. The paper describes the design and operation of the off-peak backup system and contains suggestions for improvements. A comparison is made of the electrical demand and consumption for 1976-77 (on-demand electrical backup) to 1977-78 (off-peak electrical backup). The electrical load curve of the house is described and compared with the Ontario Hydro system load curve with a brief discussion of the potentials and the drawbacks of the use of off-peak power. Reference is made to other work programs in this area. (Author)

**THE SUNDWELLINGS PROJECT.**

James B. Dekorne

The Mother Earth News, No. 46, July/August 1977, p. 99

About 70 miles north of Santa Fe—set amongst the rugged sandstone cliffs of northern New Mexico—is the Ghost Ranch, an adult study center owned and operated by the United Presbyterian Church. But Ghost Ranch is far more than a church retreat . . . It's also the site of one of the most important passive solar heating experiments in the U.S. today: the Sundwellings Project.



**Performance of Residential Solar Heating and Cooling System with Flat-Plate and Evacuated Tubular Collectors: CSU Solar House I.**

Colorado State Univ., 1978, 14p  
COO-2577-17 PC \$4.00/MF \$3.50

Measurements in Solar House I at Colorado State University have provided comparison data on space heating water heating and cooling by systems in which flat-plate collectors and evacuated tube collectors were used. Data was procured on 47 days during operation of the flat-plate collector and on 112 days when the house was heated or cooled by the evacuated tube collector system. It was concluded that the system comprising an evacuated tubular collector, lithium bromide absorption water chiller, and associated equipment is highly effective in providing space heating and cooling to a small building, that it can supply up to twice the space heating and several times the cooling obtainable from an equal occupied area of good quality flat-plate collectors and that a greater fraction of the domestic hot water can be obtained by supplying its heat from main storage. The cost-effectiveness of the system in comparison with one employing a good flat-plate collector, can be determined when commercial pricing data are made available. A summary of monthly and annual energy use for space heating, domestic hot water (DHW) heating, and space cooling is presented. The collector performance is presented. The first two months of data were obtained with the system employing flat-plate collectors, whereas heating and cooling during the following nine months were supplied by the evacuated tube collector system.

**N79-33593/** New Mexico Energy Inst., Las Cruces.  
**DEVELOPMENT OF RETROFIT ENERGY CONSERVATION AND SOLAR HEATING SYSTEMS. PHASE 1 Final Report**  
W. Reed Edgel Sep. 1978 138 p refs Sponsored in part by New Mexico Energy and Minerals Dept.  
(PB-295847/8; NMEI-20) Avail NTIS HC A07/MF A01 CSCL 13A

The type and frequency of use of various construction systems and HVAC systems in existing buildings in New Mexico was examined. Several of the most frequently occurring combinations of buildings and HVAC systems were selected; and the materials, components, and subsystems which could be used in retrofit energy conservation and solar heating applications were identified. When existing thermal envelope assessment and retrofit solar heating system design were complete, performance and cost comparisons with the unimproved buildings were made to determine cost effectiveness and energy savings. GRA

**Stratified Thermal Storage in Residential Solar Energy Applications.**

Colorado State Univ., Jun 78, 64p  
COO-4523-1 PC \$5.25/MF \$3.50

The benefits of thermal stratification in sensible heat storage were investigated for several residential solar applications. The operation of space heating, air conditioning and water heating systems with water storage was simulated on a computer. The performance of comparable systems with mixed and stratified storage was determined in terms of the fraction of the total load supplied by solar energy. The effects of design parameters such as collector efficiency, storage volume, tank geometry etc., on the relative advantage of stratified over well-mixed storage were assessed. The results show that significant improvements in system performance (5 to 15%) may be realized if stratification can be maintained in the storage tank. The magnitude of the improvement is greatest and the sensitivity to design variables is smallest in the service hot water application. The results also show that the set of design parameters which describes the optimum system is likely to be substantially different for a system employing stratified storage than for a mixed storage system. In both the waterheating and space heating applications collector flow rates lower than currently suggested for mixed storage systems will found to yield optimum performance for a system with stratified storage.

**A79-47945** Thermal storage of off-peak electrical energy in solar heating and cooling systems. R. E. Crane, H. G. Lorsch, R. L. Oswald (Franklin Research Center, Philadelphia, Pa.). In: 1978 Conference on Decision and Control, 17th, San Diego, Calif., January 10-12, 1979, Proceedings. (A79-47930 21-63) New York, Institute of Electrical and Electronics Engineers, Inc., 1979, p. 197-202, 12 refs.

Thermal storage devices of solar heating and cooling systems can be used to reduce electric demand peaks by storing off peak power. The discussion focuses on conventional control strategy, effect of thermal storage size, control strategies to reduce electrical peak demand, and off-peak load smoothing. It is concluded that off-peak storage can be used to eliminate high backup demands for solar heating and cooling systems during on-peak periods. Additional control logic development does not appear necessary, but additional hardware must be installed to eliminate on-peak demands. The cost of this hardware must be weighed against the savings achieved through reduced on-peak energy consumption. S.D.

**Solar Heating & Cooling, v.3, no.2, Apr.1978.**

<b>12</b>	Space Heat and Domestic Hot Water In Pre-fab Solar House
<b>14</b>	Space Heat and Domestic Hot Water In HUD-Sponsored Apartment Complex
<b>18</b>	Space Heat and Domestic Hot Water In Ohio In-ground Residence
<b>20</b>	Microprocessor Controls Space Heat and Hot Water Systems
<b>30</b>	Space Heat and Air Conditioning at Michigan Office Building
<b>32</b>	Space Heat and Retrofit In Wisconsin Printing Plant
<b>34</b>	Solar Pre-heat and Wastewater Heat Recovery at Commercial Laundry
<b>34</b>	Space Heat, Hot Water and Air Conditioning at Walt Disney World
<b>35</b>	Energy Conservation Package Standard in 450 Houses
<b>37</b>	Space Heat and Domestic Hot Water Systems Run on Sun

**LARGE SOLAR DOMESTIC HOT WATER HEATING SYSTEM EMPLOYS NEW SYNTHETIC HEAT TRANSFER FLUID.**

Building Systems Design, v.75, no.1, Dec.77/Jan.78, p.13-16.

Tank, collectors, pumps, heat exchanger, piping, valving and automatic controls are conventional equipment all readily available in the construction market.

Selection of an appropriate solar heat transfer fluid for the panels that could withstand severe climatic changes from winter freezing to summer high stagnation temperature necessitated that a study be performed during the preliminary design stage of the project. The heat transfer fluid selected, in addition to being subjected to annual weather conditions with wide variables, had to be non-toxic non-corrosive, and compatible with the materials of construction of the equipment, piping and valving in the system. Some of the fluids considered were ethylene glycol, propylene glycol, silicone oils and paraffinic based oils. See Table I. A synthetic oil, Brayco No. 888, manufactured by Bray Oil Company of Los Angeles, was selected because its performance data best satisfied the stringent conditions required of the heat transfer fluid for this solar system.

**ALTERNATIVE SOURCES OF ENERGY, no.33, Aug.1978.**

**Special Underground Section**

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**An Almost Perfect Passive Solar Installation by John L. Parker**

**Alternative Sources. Vol. no. 31, April 1978. p. 21-**

Southwestern architects and heating engineers are turning to passive heating systems, which really are no systems at all, but improvisations in building construction which can be readily and inexpensively adapted to collecting and retaining solar heat.

The trick is in "passive" solar conditioning. Such solar homes can make the addition of an active solar collector system - including pipes, water storage and pumps - unnecessary, or even uneconomical.

**RESIDENTIAL WATER HEATERS: ENERGY AND COST ANALYSIS.**

Fric Hirst & Robert A. Hoskins  
Energy and Buildings, Vol. 1, No. 4, June 1978,  
p. 393-400

*A detailed computer model is developed to calculate energy flows for residential electric and gas water heaters. Model equations are derived from applications of the first law of thermodynamics, analysis of manufacturers' literature, and related studies.*

*Several energy-saving changes are examined using the model. Changes for both electric and gas water heaters are: increase jacket insulation thickness, reduce jacket insulation thermal conductivity, reduce thermostat setting, and add insulation to the distribution line. Application of all these changes to an electric water heater would reduce electricity use 17% and increase initial cost 27%. Additional changes examined for gas water heaters are: reduce pilot rate, eliminate pilot and add electric ignitor and flue closure, and reduce excess air for combustion by increasing flue baffling. Implementing all these changes to a gas water heater (except addition of electric ignitor) would reduce gas use 27% and increase initial cost 26%. These results show that there are large opportunities for reducing water heater energy use with only small initial cost increases.*

**HUD SOLAR HOT WATER INITIATIVE MANUFACTURERS AND SYSTEMS.**

Solar Heating & Cooling, vol. 3, no. 5, October 1978,  
p. 41-47.

**The following list was released this summer by the New Jersey Department of Energy. Although it is fairly representative of the completed list expected to be released later this fall by the Polytechnic Institute of New York, each state will have the final say over which systems will be approved for use in its own program. For information on the approved systems, circle the reader service numbers that follow each entry.**

**INSTALLATION GUIDELINES FOR SOLAR DOMESTIC HOT WATER SYSTEMS.**

Solar Heating & Cooling, vol. 3, no. 5, October 1978, p. 22-32.

The **INSTALLATION GUIDELINES** have been prepared for participants in the H.U.D. Solar Domestic Hot Water Initiative and are intended to help avoid common installation errors associated with Solar Domestic Hot Water Systems. They are being made available to participants in the program so that

obvious errors can be avoided if a participant chooses to do his own installation or so that a participant is sufficiently knowledgeable to check that his installer has not overlooked any essential item. In no way do these Guidelines supersede local building, plumbing, electrical, fire and safety or health codes.

**CHEMICAL MIXTURE IS BASED ON MIT'S NEW SOLAR SYSTEM.**  
Solar Heating & Cooling, v.3, no.2, April 1978, p.24-7.

The proprietary process for preparing the chemical core of the solar heating tiles was developed by Cabot Corporation.

The package for the chemical core consists of an aluminum foil pouch internally lined with polyethylene film. To further protect the mixture against possible settling of solids or water separation and so extend its life, the pouch is divided into two thin, flat compartments or layers with a polyethylene film separator.

Each layer of the core's phasechange material is 3/8" thick.

The ceiling tiles which contain the core were developed by the Solar Energy Group of Architectural Research Corporation, Livonia, Michigan. Marketed under the trade name Sol-Ar-Tile®, the tiles are produced in the form of a lightweight polymer concrete panel, two feet square and 1.25" thick.

**DOYLE AKERS \$30 HOMESTEAD SOLAR WATER HEATER.**  
The Mother Earth News, no. 51, May/June 1978,  
p. 122-124.

## **SOLAR CONTROLS: CENTURY TOWN SOLAR HOMES.**

L. Robert Smeltzer  
ASHRAE Journal, vol. 20, no. 9, September 1978,  
p. 33-36

## **SOLAR FRAUD, ROUND 2.**

Carlo La Porta.

Solar Heating & Cooling, v.3, no.5, Oct.1978, p.34-36.

It is not unreasonable to expect solar manufacturers to offer warranties to cover their products, but it is unreasonable to require them to go so much further than is commonly required of other industries.

**N78-28611\*** Copper Development Association, Inc., New York, N. Y.

### **DESIGN PACKAGE FOR INSTRUMENTATION OF THE DECADE 80 HOUSE IN TUCSON, ARIZONA**

Jul. 1978 58 p Prepared for DOE  
(Contract NAS8-32244)

(NASA-CR-150730) Avail: NTIS HC A04/MF A01 CSCL 10A

A design package covering instrumentation and system design for the Decade 80 House in Tucson, Arizona is presented. The solar house is instrumented for the purpose of gathering data to determine the solar heating and cooling system performance. The use of copper in the construction of the house is a first choice construction material because it conducts heat and resists corrosion better than other materials and therefore provides a more efficient and economical system. Equipment and site specifications are reported, along with floor plans showing the location of the site instrumentation hardware. G.Y.

## **MONITORS SOLAR SPACE HEAT**

Mark Hyman, Jr.

ASHRAE Journal, vol.20, no. 3, March 1978, p.23-25

An update and performance data on a test of the feasibility of 100% solar space heating in the New England area. Results of preliminary tests were presented in the January 1976 issue of AJ.

**A78-32409**

The effect of Markovian and discrete-climate assumptions on the performance analysis of solar heating systems. G. F. Lameiro and M. C. Bryson (Colorado State University, Fort Collins, Colo.). *Journal of Applied Meteorology*, vol. 17, Mar. 1978, p. 386-389. 5 refs.

Analysis of the performance of a solar heating system is considered by means of a first-order Markov chain model for climatic and thermal-balance conditions. Computational limitations require extremely restrictive modeling for the climate, involving constant ambient temperature and two-valued discretization of insolation. Despite the restrictiveness of the assumptions, the results closely match those from dynamic simulations of system performance.

(Author)

## **DEFINITION OF EFFICIENCY FOR HYBRID HEATING SYSTEMS**

Ulrich Boone

ASHRAE Journal, vol. 20, no. 3, March 1978  
p.31-33

The author introduces a definition of energy efficiency applicable to equipment using one or more types of energy. The definition is based on the economics of operating efficiency of furnaces, boilers, space heaters, air conditioners and heat pumps. The new efficiency is named Cost Efficiency. It is the energy cost ratio of appliance output/appliance input. The output is the worth or cost of the output amount of (thermal) energy; the input is the cost of the total (fossil and electric) input amount of energy.

## **THE INDIO COOL POOL EXPERIMENT.**

David Rainbridge

Alternative Sources of Energy, No. 32, June 1978, p. 6-10

NASA TP-1296

1978

Power sources, Solar - Heating & cooling  
**SIMULATION MODEL OF A SINGLE-STAGE LITHIUM BROMIDE -  
WATER ABSORPTION COOLING UNIT.** David Miao, LeRC.  
Aug. 1978. 42p.

A computer model of a LiBr-H<sub>2</sub>O single-stage absorption machine has been developed. The model, utilizing a given set of design data such as water-flow rates and inlet or outlet temperatures of these flow rates but without knowing the interior characteristics of the machine (heat transfer rates and surface areas), can be used to predict or simulate off-design performance. Results from 130 off-design cases for a given commercial machine agree with the published data within 2 percent.

Power sources, Solar - Heating & cooling 1978

**THERMIC DIODE SOLAR PANELS FOR SPACE HEATING.**  
Shawn Buckley  
Solar Energy, Vol. 20, No. 6, 1978, p. 495-503.

**Abstract**—Thermic diode solar panels are a new method of heating buildings using solar energy. Each panel combines all the necessary elements of a complete solar energy system (collector, controls, storage heat exchangers and ducting) into a single module. They have no moving parts and they need no external power. Panel operation is discussed and thermic panels are compared to other typical solar heating systems: air heating, water heating, active and passive. Residential and commercial applications are also discussed.

The performance of thermic panels are compared to conventional solar systems. A computer simulation of thermic panels in a residential space-heating application resulted in predictions of the percentage of solar heat provided by the panels. The predictions are compared to similar analyses of conventional solar systems. Thermic panels did as well or better than conventional systems in the six climate types investigated. However, since their installed cost is less, they are expected to be more economic than conventional solar systems.

Thermic panels improve the economics of flat-plate collectors by their modularity and simplicity. Modularity reduces installation costs and raw materials cost; simplicity reduces maintenance costs. Furthermore, the panels can be integrated into the buildings structure, saving the cost of the wall or roof elements they replace.

Machine Design, v.50, no.23, p.4.

Oct. 12,  
1978

**FAMILY ENDS YEAR IN TECH HOUSE.** (Preliminary results from year-long energy conservation study at NASA's LeRC Technology Utilization House).

NASA,  
Langley Research Center

Buildings, Solar

COLLEGES, UNIVERSITIES, VOCATIONAL-TECHNICAL  
SCHOOLS OFFERING SOLAR INSTALLATION PROGRAMS  
Solar Heating & Cooling, vol. 3, no. 6, December 1978,  
p. 32-35.

**N80-16485\*** General Electric Co., Philadelphia, Pa. Space  
Div.  
**PROTOTYPE SOLAR HEATING AND COMBINED HEATING  
COOLING SYSTEMS**  
DOE 2 Oct. 1978 44 p Sponsored in part by DOE  
(Contract NAS8-32092)  
(NASA-CR-161340; QR-9) Avail: NTIS HC A03/MF A01 CSCL  
10A

The design and development of eight prototype solar heating and combined heating and cooling systems is discussed. The program management and systems engineering are reported, and operational test sites are identified. A.W.H.

**YOU CAN BUILD NASA'S LOW-COST SOLAR HEATING  
SYSTEM**

Graham Gross  
Popular Science  
Vol. 212 no. 2 Feb. 1978  
p. 106-108

NASA's technical expertise,  
low-cost materials, plus your  
DIY labor could make solar  
heat practical for your home

**SOLAR HEATING & COOLING: AN ELECTRIC UTILITY  
PERSPECTIVE**, by Dan Nathanson and John E. Cummings.  
ASHRAE Journal, vol. 20, no. 12, December 1978,  
p. 42-46.

Solar heating and cooling systems that have electrical auxiliary power should be designed on the basis of a realistic examination of costs on both sides of the electrical meter. In this way, configurations can be identified which are compatible with the needs of both the consumer and the utility. Here, an approach for evaluating preferred solar heating and cooling systems—from the standpoint of the consumer and of the electric utility—which considers energy conservation measures and control of electric demand by load management techniques, is discussed. This paper was presented at the 5th Energy Technology Conference and Exposition in Washington, DC.

## COOLING SUBSYSTEM DESIGN IN CSU SOLAR HOUSE III

D.S.Ward, G.O.G. Lof and T. Uesaki

Solar Ener., v.20, no. 2, 1978, p.119-126.

Design of the cooling subsystem for Colorado State University Solar House III is based on the use of a lithium bromide absorption chiller and a "cool" storage unit; the cool storage being located functionally between the absorption machine and the cooling load distribution system. The distribution system consists of a liquid-to-air heat exchanger and an air duct distribution system. The choice of a lithium bromide absorption cooling machine was based on the ready availability of the unit for research purposes, the demonstrated capability of the unit to operate within the temperature capabilities of solar-delivered heat from flat-plate collectors and unpressurized storage, and the accessibility of existing research data and experience. In addition, current efforts at improving the LiBr absorption unit are more extensive than for other cooling equipment, allowing for its earliest potential use as a commercial unit for residential applications.

**SIMULATIONS OF THE PERFORMANCE OF OPEN CYCLE DESICCANT SYSTEMS USING SOLAR ENERGY**, by J. S. Nelson, W. A. Beckman, J. W. Mitchell and D. J. Close.

Solar Energy, vol. 21, no. 4, 1978, p.273-278.

A78-19834

**Advances in solar water heating for domestic use in Australia.** J. T. Czarnecki and W. R. W. Read (Commonwealth Scientific and Industrial Research Organization, Div. of Mechanical Engineering, Highett, Victoria, Australia). *Solar Energy*, vol. 20, no. 1, 1978, p. 75-80.

A method enabling retrofitting of solar collectors to existing domestic, low pressure electric water heaters has been developed and tested. The performance of the proposed system was found to be comparable with the performance of conventional solar water heaters when the size of the solar collectors is suitably matched to the average daily consumption of hot water. Other developments described are a solar energy operated pump and an airlift pump, both suitable for circulation of water in domestic solar water heaters, and an electronic controller for the circulating pumps. (Author)

## THE RESULT OF COOLING OPERATION OF YAZADI EXPERIMENTAL SOLAR HOUSE "ONE".

Toshihiro Ishibashi

Solar Energy, Vol. 21, No. 1, 1978, p. 11-16.

The purpose of constructing the Yazaki Experimental Solar House One has been to grasp in detail what factors would be involved when practically applying solar energy to operate a residential heating cooling and water heating system with the expectation that this would lead not only to improvement of the conventional air conditioning equipment but also to the development of practical equipments for a solar house.

Cooling operation of the solar house was started on 21 July 1974 and continued for one year including heating operation. Newly developed solar collectors as well as an updated solar heated absorption chiller have been installed at the beginning of June 1975 along with some improvements on the house. At present, cooling operation is operating successfully.

## CORROSION PROBLEMS IN SOLAR ENERGY SYSTEMS.

P.D. Thompson and M.B. Hayden.

Materials Performance, v.17, no.2, Feb.1978.

*Corrosion problems associated with Al liquid filled solar energy systems for small scale ambient temperature operation are listed and suggested preventives and control itemized. Comments pertain mainly to systems such as that developed at the Beltsville Agricultural Research Center which consists of Al piping and components. Suggestions are made concerning water controls, inhibition, exclusion and scavenging of oxygen, pH control and design, and operation modes tending to control access of oxygen to the system. Also considered are such factors as flow velocity, elimination of galvanic couples, deleterious ion solution in water, controls for displaced vapor, avoidance of freezing, and possibility of cathodic protection. A nontoxic inhibitor, such as a silicate is recommended. Economic considerations and some magnitudes are discussed.*

Solar Heating & Cooling, vol. 3, no. 5, October 1978

52	CETA Workers Install Rhode Island System
53	Domestic Water System Designed for Mid-Atlantic Region
54	Collectors Vertically Mounted in Domestic Hot Water Retrofit
56	Trickle-Flow Collectors are Main Component of Simplified System
57	Impressions Restaurant Combines Active and Passive Systems

### IS SOLAR ENERGY AN ANSWER?

Gordon F. Tully.

House Beautiful, Jan. 1978, p. 64, 65, 98,

Dazzling in theory, potential power from the sun has enjoyed a heyday in the press. We asked an expert to tell the truth about solar energy for now and the years ahead.

SOLAR HEATING & COOLING, v. 3, no. 6, December 1978.

### APPLICATIONS

10	First Operational Solar Energy Installation in Textile Industry
12	Seaside Solar Saltbox Applies Water-to-Air in Drain-Back System
14	Active & Passive Make Prominent Statement
16	Solar Cleans Up at Doughnut 'Factory'
21	Solar Meets Environmental Health Laboratory's Hot Water Demand
23	Drain-Down-System Assures Freeze Protection
28	Villa Doubles DHW Collection with Two Solar Systems
30	A Key to Solar Heat in Middle Income Homes

### ABSORPTION EQUIPMENT FOR SOLAR AIR CONDITIONING.

Lynn A. Stump

Building Systems Design, Vol. 75, No. 4, June/July, 1978, p. 36-45.

Following is the outline of a talk about "some interesting things which have been learned to date about absorption equipment for solar air conditioning.

THE SOLAR DECISION BOOK - DECISION 14: BANK THE COLLECTED ENERGY, by Richard H. Montgomery / Jim Budnick.

Solar Heating & Cooling, vol. 3, no. 6, December 1978, p. 36-42.

A building's hot water needs vary according to the occupant's lifestyle or working schedule. A building's space heating needs vary according to the weather. The collectors in a solar energy system normally do not collect usable energy for more than six hours a day. With storage capabilities, the system can provide heat and hot water as needed, night or day, regardless of the weather.

N79-28632/ Pennsylvania Univ., Philadelphia. Dept. of Mechanical Engineering and Applied Mechanics.

#### TEMPERATURE MEASUREMENT AND SENSOR SELECTION FOR SOLAR HEATING AND COOLING SYSTEMS

Noam Lior 1978 21 p refs Presented at Conf. on Performance Monitoring Tech. for Evaluation of Solar Heating and Cooling Systems, Washington, D. C., 3-4 Apr. 1978

(Contract EG-77-S-02-4142)

(COO-4142-3; Conf-780432-5)

Avail: NTIS

HC A02/MF A01

The different methods for temperature and temperature difference measurement are described as to their applicability to solar heating and cooling systems. The major commercial temperature sensors are surveyed, and their technical and economic aspects are discussed. Installation and calibration techniques are recommended. The temperature measuring system implemented in the University of Pennsylvania Solar Row House as a consequence of the above considerations is described.

DOE

N79-29656/ Pennsylvania Univ., Philadelphia. Dept of Mechanical Engineering and Applied Mechanics.  
**STANDARDS APPLICABLE TO PERFORMANCE MEASUREMENT OF SOLAR HEATING AND COOLING SYSTEMS**  
 Noam Lior 1978 8 p  
 (Contract EG-77-S-02-4142)  
 (COO-4142-2; Conf-780432-4) Avail: NTIS  
 HC A02/MF A01

The advantage of the utilization of existing standards in the performance monitoring of solar heating and cooling systems is discussed. Existing applicable measurement standards and practices are listed. DOE

TK Southeastern Region 3 Conference, Atlanta, Ga., 1978.  
 5

.I3849 A creative exchange of ideas ...cl978  
 1978 2. The Use of TRNSYS to Simulate Solar Heating and Cooling Systems 257

Cooling Systems

K. C. Bordoloi and J. Meadway  
 Department of Electrical Engineering  
 University of Louisville  
 Louisville, KY

4. A Microprocessor-Based Control System for Solar Heating and Cooling 545

R. A. Payton and T. M. Murray, Jr.  
 Department of Electrical Engineering  
 University of Louisville  
 Louisville, KY

SOLAR HEATING FROM THE HEART, by Wendell T. Robie and Robert M. McChesney.

Sunworld, vol. 2, no. 3, August 1978, p.63-65.

Requests for solar-energy financing have been coming to Heart Federal Savings for several years. In researching these requests for loans, this northern California bank found that due to recent sharp increases in utility rates, certain savings could be made by the use of solar energy. For this reason, Wendell T. Robie, President of the Association, together with the Board of Directors approved the use of solar energy for their new office building in Auburn, California.

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DESIGN OF SOLAR HEATING AND COOLING SYSTEMS FOR NONRESIDENTIAL BUILDINGS IN THE EAST NORTH CENTRAL REGION OF THE UNITED STATES.

R.K. Newman.

NACON 78 (IEEE 1978 NATIONAL Aerospace and Electronics Conference, v.2, 1978, p.862-

Descriptions of various solar heating and cooling projects in an area in which 60 percent of the U.S. population lives are given with emphasis on the Troy-Miami County Library system which was put in operation this past winter. Instrumentation and control strategies for the various modes of operation are discussed for this system, the Columbus Technical Institute Phase V, and the Stark County Library buildings which will provide both solar heating and cooling.

The use of solar energy to provide a large quantity of domestic hot water, swimming pool heat, and assistance to heat pumps is discussed with respect to the Deer Creek Lodge solar project. Brief descriptions of solar heating systems for a Dayton Fire Station and a Mound Laboratories building are also given.

SOLAR HEATING & COOLING: STANDARDS FOR A MATURING INDUSTRY, by Mat Heyman.

Dimensions, vol. 62, no. 12, December 1978, p.5-10.

APPLICATION OF SOLAR COLLECTORS TO RESIDENTIAL SYSTEMS.

James Norman

Building Systems Design, Vol. 75, No. 4, June/July, 1978, p. 10-18.

Residential solar systems are not particularly complicated but do require good piping and installation practices and some innovative thinking. Collector location, slope, and orientation are important, but the southern parts of our country, especially from Central Florida southward, give a designer a very broad latitude, especially for systems with a relatively constant year-round energy requirement, such as heating domestic water. The economics of a solar system should be handled as a return on the investment required for the system rather than as a strict pay back, since the solar system is an investment and should, if properly applied, maintain its value for many years after installation.



## SAWING SOLAR COSTS IN HALF.

A. Weinstein, et al.

Solar Heating & Cooling, v.3, no.5, Oct.1978, p.48-51.

### How It Works

The Westinghouse Native Sun™ Solar-Assisted-Templifier (S-A-T) hot water system is a combination of a solar energy collection system with a Templifier heat pump. They are piped together physically and operationally.

A79-31419

NRC solar monitoring program. S. A. Barakat, W. E. Carscallen, and B. E. Sibbitt (National Research Council, Div. of Building Research, Ottawa, Canada). In: Renewable alternatives: Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 14 p.

As part of the federal solar heating program, the Division of Building Research of the National Research Council is responsible for an on-going monitoring program of various solar installations. The aims of the program are to determine the solar contribution to the heating needs of buildings, to provide technical data for validating solar system simulation design methods and to permit analysis of subsystem performance. The paper describes the different levels of monitoring used by NRC and lists the buildings in which these monitoring systems are or will be installed. In particular, a description is given of the monitoring equipment installed in twelve federally-funded solar heated homes, as well as their installation and calibration. Some of the problems associated with the monitoring systems are also discussed. (Author)

## YOU CAN BUILD NASA'S LOW-COST SOLAR HEATING SYSTEM

Graham Gross

Popular Science

Vol. 212 no. 2 Feb. 1978

p. 106-108

ORIGINAL PAGE IS  
OF POOR QUALITY

Engineers at NASA's Langley Research Center in Hampton, Va., have written a do-it-yourself handbook for homeowners. It describes how to build and install a solar heating system that could cut 40 percent from the heating bill of a house insulated to 1974 FHA minimum standards.

## TK5.I3848 1978 Southeastern Region 3 conference

### 5. A Microprocessor-Based Instrumentation System for 549

Solar Energy Research

C. H. Spencer and T. M. Murray, Jr.

Department of Electrical Engineering

University of Louisville

Louisville, KY

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### Greater Los Angeles Area Energy Symposium, Los Angeles, 1978.

#### Greater Los Angeles Area Energy Symposium

• Instrumentation for Optimizing Solar Heating Systems — Gary L. Parker, Jet Propulsion Laboratory

- I. Los Angeles Council of Engineers and Scientists.
- II. American Nuclear Society. Los Angeles Section.
- III. Series: Los Angeles Council of Engineers and Scientists. Proceedings series — Los Angeles Council of Engineers

Solar energy heating systems involve the collection of an intermittently available thermal energy resource to meet an energy need that is usually continuous and describable only in statistical terms. The energy must be drawn from storage during times when the demand exceeds the immediate supply. The collection capability must be sufficient to meet the immediate demand and to recharge storage during collection opportunities. The optimization of such a system requires appropriately sizing the solar collection apparatus and heat storage means in relation to the expected heat demand. Integrations of the time histories of available insolation and heating load can provide information to appropriately size the solar collector if it is assumed that the system contains adequate thermal storage capacity. To accurately determine what would constitute adequate storage, however, requires knowledge relative to the time integral of the instantaneous difference between the insolation and the load. Data is not directly available in this format since it is a function of the particular system being designed. In addition, one of the principle problems encountered in many locations, especially rural areas, is the acquisition of appropriate meteorological data. An instrumentation system has been assembled which gathers the required data and preprocesses it to a form that directly facilitates the energy system design. It contains a pyranometer to measure available insolation, an ambient temperature transducer to estimate heating load and electronic circuitry to digitally integrate both of these as well as their difference as functions of time. The measurements are scaled and processed such that the data produced can be directly applied to the design optimization process. This treatise will describe the analytical basis of the instrumentation, the prototype version of it and the results of a trial operation period.

**N79-30782/** Los Alamos Scientific Lab., N. Mex.  
**COMPARATIVE ECONOMICS OF PASSIVE AND ACTIVE SYSTEMS**

J. F. Roach, S. A. Noll, and S. Ben-David 1978 41 p refs  
 Presented at the Intern. Symp Workshop on Solar Energy, Cairo,  
 16-22 Jun. 1978  
 (Contract W-7405-eng-38)  
 (LA-UR-78-1878; Conf-780667-3) Avail: NTIS  
 HC A03/MF A01

As the interest in solar energy applications for residential space heating grows, it becomes imperative to evaluate the economic performance of alternative designs. One passive design is concentrated on the thermal mass storage wall. The economic performance of this design is examined and subsequently contrasted with one active design-the air collector/rock storage system. Architectural design criteria, solar performance characteristics, and the incremental solar cost of each design is briefly reviewed. Projections of conventional energy prices are discussed, along with the optimal sizing/feasibility criterion employed in the economic performance analysis. In addition, the effects of two incentive proposals-income tax credits and low interest loans-upon each design are examined. Results are reported on a state-by-state basis for the U.S., with major conclusions summarized for each design. It is generally the case that incentives greatly enhance the economics of both system designs, although the contrast is greater for the passive design. Also, against the less expensive conventional fuels (natural gas and heating oil) the passive design was shown to offer a more cost effective alternative than the active system for most states. DOE

**N79-31825/** Sandia Labs., Albuquerque, N. Mex.  
**HAZARDOUS PROPERTIES AND ENVIRONMENTAL EFFECTS OF MATERIALS USED IN SOLAR HEATING AND COOLING (SHAC) TECHNOLOGIES: INTERIM HANDBOOK**

J. Q. Searcy, ed. Aug 1978 226 p refs  
 (Contract EX-76-C-04-0789)  
 (SAND-78-0842) Avail: NTIS HC A11/MF A01

General background information related to SHAC systems, how a particular material was chosen for this handbook, and codes and standards are given. The following are included: classification scheme and general properties of materials used in SHAC systems; chemical composition, thermal degradation products, and thermoxidative products; toxic properties and other potential health effects of SHAC materials; fire hazard properties of SHAC materials; and environmental effects of and disposal for SHAC materials. DOE

**N80-10801\*/** Honeywell, Inc., Minneapolis, Minn.  
**OCMULGEE NATIONAL MONUMENT VISITOR CENTER SOLAR HEATING AND COOLING SYSTEM DESIGN REVIEW DATA**

May 1978 72 p refs Prepared for NASA and DOE  
 (Contract NAS8-32093)  
 (NASA-CR-150706) Avail: NTIS HC A04/MF A01 CSCI  
 10A

The design of a solar heating and cooling system is documented. Solar collectors, design approaches, system trade studies, and preliminary specifications are discussed. K.L.

**N80-10853/** Colorado State Univ., Fort Collins Solar Energy Applications Labs

**PRELIMINARY ANALYSIS OF A TOTAL SOLAR HEATING SYSTEM** Final Report, Dec. 1977 - Sep. 1978

James A. Lellar, P. Burns, and C. B. Winn Oct 1978 28 p  
 (Contract EG-77-S-02-4546)  
 (COO-4546-4) Avail: NTIS HC A03/MF A01

A set of computer simulation programs was developed such that the programs provide a useful design tool for the design of total solar heating systems. DOE

**N80-10858/** Honeywell, Inc., Minneapolis, Minn. Energy Resources Center.

**COST-EFFECTIVE CONTROL SYSTEMS FOR SOLAR HEATING AND COOLING APPLICATIONS** Final Report

Jane H. Pejsa, W. W. Bassett, S. A. Wenzler, K. H. Nguyen, and T. J. Olsen Sep. 1978 180 p refs  
 (SAN-1592-1) Avail: NTIS HC A09/MF A01

A methodology is defined and the results are presented to arrive at control recommendations for a variety of climate control system designs, applications and regions, strategies, functions, sensors, actuators, and the controllers themselves. The bulk of the study effort - an attempt to simulate and evaluate system performance for several representative residential and commercial heating and cooling designs and thus to derive improved performance techniques within cost effective control systems - are discussed. DOE

**N80-10848/** Notre Dame Univ., Ind Dept of Electrical Engineering

**OPTIMAL CONTROL STUDIES OF A SOLAR HEATING SYSTEM**

M. Somasundaram, James L. Melsa, and Donald R. Farris 1978  
 6 p refs Presented to IEEE Midcom on Electron., Dallas, Tex.,  
 13 Dec. 1978

(Contract W-7405-eng-38)  
 (LA-UR-78-2556; Conf-781208)  
 HC A02/MF A01

Avail: NTIS

Performance bounds were established for a heating, ventilating and air conditioning system in a solar heated and cooled building. Perfect knowledge of environmental conditions such as ambient temperature, wind velocity and insulation was assumed in order to determine whether prior knowledge of such information can be effectively employed to reduce the amount of auxiliary energy used. The optimal control study is based on a model of the 660000 sq. ft. National Security and Resources Study Center at the Los Alamos Scientific Laboratory. DOE

TL National Aerospace and Electronics Conference,  
603 Dayton, Ohio, 1978.

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1978

1. Design and Solar Heating and Cooling Systems for Nonresidential Buildings in the East North Central Region of the United States, Ronald K. Newman, University of Dayton Research Institute
2. Installation and Initial Operation of a Solar Heating System at the Troy-Miami County (Ohio) Public Library, Richard G. Coy, Dale H. Whitford, University of Dayton Research Institute.

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A79-31432 Collector and storage efficiencies in solar heating systems. K. G. T. Hollands, J. W. Chinneck, and M. Chandrasekar (Waterloo, University, Waterloo, Ontario, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978, Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 13 p. 10 refs. Department of Supply and Services Contract No. OSU77-00099.

A general definition of the efficiency of a solar collector operating in a solar energy system is presented which gives a fair method of comparison of different collectors operating in that particular application. Based on comparison between the areas required for the actual collector and that of a perfect collector - both giving the same fraction solar - the definition permits the definition of the average value of the collector input parameter. The concept of the perfect collector also leads to a fair definition for the efficiency of the storage component in a solar heating system. These parameters are evaluated for the special case of residential space heating and service hot water systems of the standardized f-chart type operating in a number of Canadian cities. Simple methods for collector comparisons result from the study and indications are that a simple solar system design method will follow.

(Author)

A79-31430 A cost effective vertical air/water solar heating collector. T. H. Markowitz and R. L. Hummel (Toronto, University, Toronto, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978, Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 12 p. 13 refs.

A description is presented of a vertical air/water collector which combines high efficiency with low cost. The low-cost characteristics of the total system are obtained by utilizing an air system for heat collection along with a water system for heat storage. The heat exchanger is in the top of the collector. It is protected from freezing, and is available to transfer heat from the collector to storage, or from

storage to the building. The collector can be constructed from inexpensive materials. The incident direct solar radiation is almost doubled by employing a reflector, made of inexpensive aluminized Mylar plastic film.

G.R.

A79-31424 New approaches for the appropriate use of solar energy in northern climates. T. A. Lawand, H. P. Budgen, C. Ives, J. LeNormand, A. Skelton, and L. Ghanime (McGill University, Sainte Anne de Bellevue, Quebec, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978, Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 18 p. 6 refs.

A number of novel approaches in the field of solar heating are proposed for an investigation regarding a utilization in cold climate areas, taking into account attached solar rooms or greenhouses, modified Trombe walls, total roof canopies, solar heat pipes, and the long term potential of storing ambient heat and cold for the climatization of buildings. It is felt that these systems individually or in combination with standard passive heat gain techniques, will make significant contributions to the solar heating field in the future. G.R.

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Institute of Electrical and Electronics Engineers. Region 6.

Electric Power Research Institute Residential Solar Heating and Cooling Project

T. Michael Lechner

Public Service Company of New Mexico  
Albuquerque, NM

The Public Service Company of New Mexico (PNM) and the Long Island Lighting Company (LILCO) are participating in a project funded by the Electric Power Research Institute (EPRI). The project will result in five residential solar augmented heating and air conditioning systems for the Albuquerque area and five for the Long Island area. The prime contractor, Arthur D. Little Company (ADL), is expected to develop a model capable of predicting solar systems that will operate in harmony with utility systems. An important feature of this model will be the ability to forecast the impact of solar systems on a typical utility grid.

PNM and LILCO are working in the capacity of participating utilities and advise EPRI and ADL on questions they have regarding the model to include data input the utilities would most likely have available and outputs that would prove most helpful. Each utility has provided specific information unique to its respective operation such as cost of fuel, incremental demand costs, and load curves by the month for typical holidays and weekdays.

The model developed will use the information given by the utilities as a basis for establishing hypothetical rate structures that will closely parallel actual cost of electric energy. These will be needed to compute the homeowner's life cycle costs for the solar system.

The follow-on phases will consist of the creation of working drawings for the homes, building the homes, and also data gathering on the residence in use.

## Environmental Action Reprint Series

### SOLAR ENERGY CALCULATIONS & PROGRAMS FOR POCKET PROGRAMMABLE ELECTRONIC CALCULATORS by Henry C. Landa

This manual has a number of solar energy system calculations, designed for use on algebraic logic calculators. Step by step programs for Depreciation, Furnace Size, Building Heat Loss, Heat Bin Size, Profitability Index, Parabolic Reflector, Surface Insulation, and Water Heating Systems.  
62 pages, paperbound (1978) \$4.00

- TH 7413 Dean, Thomas S.  
.D43 Thermal storage / T. S. Dean. — Philadelphia : Franklin Institute Press, 1978.  
61 p. : ill. — (Solar energy series)  
Includes bibliographical references.  
ISBN 0-891680-05-5

The problems of thermal storage are examined in terms of the design characteristics of systems to be used with solar heating units (active and passive heating, water, rocks and hybrid systems, and specially designed houses).

- TJ N10 Aspen Energy Forum, 4th, Aspen Institute for Humanistic Studies, 1977.  
.A79 Solar architecture : proceedings of the  
1977 Aspen Energy Forum 1977, May 27, 28, and 29, 1977, Aspen, Colorado / editors, Gregory E. Franta, Kenneth R. Olson ; graphics, T. Michael Manchester. — Ann Arbor, Mich. : Ann Arbor Science Publishers, c1978.  
ix, 331 p. : ill. ; 24 cm.  
Includes index.

How to Buy Solar Heating... Without Getting Burnt! Malcolm Wells and Irwin Spelgang, Rodale Press Inc., Emmaus PA 18049, 1978, 266pp., \$6.95 paper

This book is an answer to a prayer. It helps to answer such questions as whether to buy solar heating, what type is best for specific needs and tastes, how to choose a contractor, how to make sure he does the job, how to apply for a mortgage or loan.

In addition to providing thorough coverage, it's fun to read. Topics such as insulation, shutters, climate, mortgages, contracts and building codes are important, but can make dull reading. Not here! For example, amid the checklist for materials and equipment necessary for insulating an attic, a parenthetical note details the hazards of positioning walkboards carelessly: "Nothing is quite so surprising as stepping on the end..., overhanging a rafter, and having [the walkboard] pivot downward as your foot crashes through the ceiling below." Wells and Spelgang — veteran solar-house designers — write with so much sparkle that the reader can hardly lay the book down.

- Z 5853 Eggers-Lura, A.  
.H4 Solar energy for domestic heating and  
E45 cooling : a bibliography with abstracts,  
1978 and a survey of literature and information sources / A. Eggers-Lura. — Oxford : New York : Pergamon Press, 1978.  
vi, 229 p. — (Pergamon European Heliostudies ; v. 2)  
Includes index.  
ISBN 0-08-022162-1  
1. Dwellings Heating and ventilation  
—Bibliography 2. Solar heating—Bibliography  
ography. 3. So- lar air conditioning--

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Montgomery, Richard H.

The solar decision book : your guide to making a sound investment / by Richard H. Montgomery with Jim Budnick. -- Midland, Mich. : Dow Corning Corp., c1978.  
396 p. in various pagings : ill.

In The Solar Decision Book, I have attempted to present a logical and practical approach to good solar system design. I have religiously used information which has been proven in the field.

The book is opinionated. The opinions are mine. Some may not agree with them, while others will recognize a restatement of their own work.

I would like to give the reader the same challenge which I give my colleagues at Dow Corning: "The proven performance of certain components and systems has led me to the conclusions in the book. If you can present facts which I have ignored or overlooked that might require changing those conclusions, I will be happy to consider them. Until you do, this is where we start."

As a new industry, the solar energy industry is having its share of growing pains. Many systems are failing. Many companies are questioning further involvement.

But, energy shortages and spiralling prices demand the continued development of solar technology and other "soft" energy systems. They are essential for our future. We must press ahead.

Write to me if you feel that I am wrong. And, especially write if you have a suggestion for a better approach, component, or system. Also, write if you have facts which I have seemingly ignored or overlooked. The solar business needs all of us working together.

#### SOLAR ABSORPTION SYSTEM FOR SPACE COOLING AND HEATING.

I. Shwarts and A. Shitzer.

ASHRAE J., Nov.1977, p.51-

Space heating and cooling are probably among the most promising ways for solar energy utilization in the near future. The purpose of the present study is to investigate the feasibility of operating the solar absorption system for space cooling and as a heat pump for space heating. Such an approach permits the year-round utilization of the rather expensive system of solar collectors which has to be installed in any case. The thermodynamic analysis is performed for various ranges of the operation parameters selected to conform to typical Israeli climatic conditions. A number of systems have been considered. The results indicate that the  $H_2O$ -LiBr heat pump system may provide considerable energy savings in year-round air conditioning application.

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Harkness, Edward L.

Solar radiation control in buildings / by Edward L. Harkness and Maden L. Mehta. -- London : Applied Science Publishers, c1978.

xiii, 271 p. : ill. ; 23 cm. -- (Architectural science series)

Includes bibliographical references and index.

ISBN 0-85334-764-6

I. Architecture and solar radiation. I. Mehta, M. L., joint author. II. Title. 720

NA  
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.S6  
W74

Wright, David, 1941-

Natural solar architecture : a passive primer / by David Wright ; technical advice, Jeffrey Cook ; ill., Dennis A. Andrejko. -- New York : Van Nostrand Reinhold Co., c1978.

245 p. : ill. ; 22 x 30 cm.

Bibliography: p. 240-243.

Includes index.

ISBN 0-442-29585-5

1. Architecture and solar radiation. 2. solar heating. 3. Solar houses.

I. Title.

728

#### SOLAR ENERGY AND LARGE BUILDING HVAC SYSTEMS: ARE THEY COMPATIBLE?

M. Meckler.

ASHRAE J., Nov.1977, p.43-

A well planned building designed with energy conservation in mind goes hand in hand with the basic energy requirements essential for compatible solar heating and cooling systems. This article is based on a Seminar presentation by the author during ASHRAE's 1977 Annual Meeting in Halifax, N.S., Canada.

**N79-31814/** Department of Energy, Washington, D. C. Office of Conservation and Solar Applications.

**PASSIVE SOLAR ENERGY PLANNING AID KIT FOR THE BUSINESS COMMUNITY AND GENERAL PUBLIC**

1978 124 p Presented at the 2d Natl. Passive Solar Conf., Philadelphia, 16 Mar. 1978

(Contract EM-78-C-01-4228)  
(CONF-780337-P2) Avail: NTIS HC A06/MF A01

Twenty-three articles are presented each containing information representative of some planning aid aspect of the state of the art in passive solar energy. The articles are organized into four categories: (1) passive solar approach, (2) real buildings in different locations, (3) greenhouses and greenrooms, and (4) design ideas and illustrations. R.E.S.

**N79-31813/** Department of Energy, Washington, D. C. Office of Conservation and Solar Applications.

**PASSIVE SOLAR ENERGY PLANNING AID KIT FOR BUILDING DESIGN ARCHITECTS AND PLANNERS**

1978 97 p refs Presented at the 2d Natl. Passive Solar Conf., Philadelphia, 16 Mar. 1978

(Contract EM-78-C-01-4228)  
(CONF-780337-P1) Avail: NTIS HC A05/MF A01

Fourteen articles are presented each containing building design and planning information for passive solar energy application. The articles are organized into three categories: (1) planning and analysis, (2) residential buildings, and (3) office buildings. In a separate section passive design ideas are given along with planning consideration tips. DOE

**A79-13899** Predicting the performance of passive solar-heated buildings. E. Mazria (Matrix, Albuquerque, N. Mex.), M. S. Baker (Oregon, University, Eugene, Ore.), and F. C. Wessling (New Mexico, University, Albuquerque, N. Mex.). *Sunworld*, vol. 2, May 1978, p. 42-45.

The paper describes an analytical model used to predict the performance of thermal-mass materials located in a solar-heated space heated by a direct-gain passive system. Three configurations of thermal storage mass are considered, and computer simulation results showing the relation between external and internal temperatures for the three configurations and for different materials are presented. The results indicate that passive solar-heating systems can supply a significant portion of a building's winter space-heating requirements and can maintain relatively stable indoor air temperatures. M.L.

**A79-46909** Investigation of the temperature distribution over the width of the screen of low-temperature solar water heaters with tubular heat receivers. G. Ia. Umarov, R. R. Avezov, and N. A. Kakharov (Akademiia Nauk Uzbekskoi SSR, Fiziko-Tekhnicheskii Institut, Tashkent, Uzbek SSR). (*Geliotekhnika*, no. 6, 1978, p.

41-46.) *Applied Solar Energy*, vol. 14, no. 6, 1978, p. 33-37, 7 refs. Translation.

(Previously cited in issue 11, p. 2056, Accession no. A79-28671)

**A79-31445** Measured and modeled passive performance in Montana. L. Palmiter, W. Caswell, and R. J. Corbett (National Center for Appropriate Technology, Butte, Mont.). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 9 p.

Several passive solar test units have been constructed at The National Center for Appropriate Technology. The design, instrumentation and performance of the direct gain and Trombe wall cells are discussed. Preliminary results of a simple computer model for simulating air and storage wall temperatures are presented. (Author)

**2ND NATIONAL PASSIVE SOLAR CONFERENCE.**

Tom P. Abeles  
Alternative Sources of Energy, No. 32, June  
1978, p. 30-32

Solar  
collectors

DESIGN MANUAL FOR  
SOLAR WATER HEATERS

(No. 201) \$5.00

CR-142,792

HORIZON INDUSTRIES  
12606 Burton Street  
North Hollywood, CA 91605

"the only place I've seen some of the necessary calculations" - J. Baldwin, The Coevolution Quarterly (the ongoing Whole Earth Catalog)

1977

This definitive manual is based on years of experience by a practicing solar design group. It includes a step by step procedure for selecting the optimum collector and storage tank, computing the fuel savings, and finding the system's rate of return for both constant and increasing fuel rates. To aid those not familiar with solar water heating, the manual contains introductory material and wiring-plumbing diagrams for a complete range of systems. Profusely illustrated, with many worked out examples, it will allow the engineer to professionally design solar water heaters. 40 Pages

Solar Energy, v.19, 1977, p669-75.

## LIGHTWEIGHT THERMAL STORAGE FOR SOLAR HEATED BUILDINGS†

TIMOTHY E. JOHNSON

Department of Architecture, Massachusetts Institute of Technology, Cambridge, MA 02139, U.S.A.

(Received 15 August 1976; in revised form 24 January 1977)

**Abstract**—A new building element is introduced that greatly improves the thermal and architectural performance of passively heated structures. Insulated ceiling tiles charged with thin layers of phase change material are used to stabilize room temperatures and store large quantities of heat without using weighty materials which are expensive to support in multiple story structures. Experimental and analytical results are presented which detail the tile performance.

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1977

Aspen Energy Forum, 4th, Aspen Institute for  
Humanistic Studies, 1977.

Solar architecture : proceedings of the  
Aspen Energy Forum 1977, May 27, 28, and  
29, 1977, Aspen, Colorado / editors, Gregory  
E. Franta, Kenneth R. Olson ; graphics, T.  
ch. :

While the main emphasis is on passive solar design, attention is  
also directed to greenhouse construction, active systems, alternative  
energy sources, and educational programs on solar energy. Topics  
include prediction of performance of passive solar-heated buildings,  
energy-processing building materials, self-inflating movable insula-  
tion, northern windows and solar architecture fallacies, energy flows  
in greenhouses, solar collector sizing, and wind power as a viable  
energy source. Case studies of projects in Colorado are reported, and  
solar energy resource centers and their programs are characterized.

## THERMAL EVALUATION OF A HOUSE USING A MOVABLE-INSULA- TION HEATING AND COOLING SYSTEM

Philip W.B. Niles

Solar Energy, v.18, no. 5, 1976, p. 413-419

**Abstract**—A full-size house utilizing a heating and cooling system composed of roof water-bags intermittently covered with insulation was designed and tested in Atascadero, California (35°N lat.). Twenty centimeters (8 in.) of water sealed in plastic bags with inflatable covers rested on the metal ceiling which covered the 102 m<sup>2</sup> living space. The movement of the 5 cm thick polyurethane insulation panels were automatically controlled to maximize the heating and cooling potentials of the system. With family occupancy, the house remained comfortable in both the heating and cooling seasons which were typified by daily average outdoor temperatures of 8°C (47°F) and 22°C (72°F) respectively. No auxiliary heating or cooling systems were employed during the 9-month test. Operating characteristics were favorable. Design parameters and performance data are given.

## Environmental Action Reprint Series

SUN EARTH—HOW TO APPLY FREE ENERGY  
SOURCES TO OUR HOMES AND BUILDINGS,  
by Richard Crowther of Solar Group Architects.  
Considered to be the sourcebook for information  
on Solar Passive building design. Explains, with  
hundreds of illustrations, how to make your  
house and site act as a solar collector. Detailed  
descriptions of houses and commercial buildings  
designed and built by the Solar Group dramati-  
cally increase one's awareness as to the effective  
application of Solar Passive design. Active  
collector systems are often integrated into the  
passive designs, resulting in energy optimized  
structures.

232 pages, paperbound (© 1977) \$8.95

TJ 810.  
C76 1976

HERE'S A PASSIVELY HEATED AND COOLED HOUSE  
THAT YOU CAN AFFORD --- AND WILL WANT!

Jesse Savell

The Mother Earth News, No. 48, November/  
December 1977, p. 117-118.

Savell System dwelling ac-  
complishes all its magic energy savings  
—and a great deal more—without looking  
“strange” or in any way different from the  
kind of housing that we’ve all grown used  
to. And the cost of one of these “wonder  
structures”—complete on a city lot, in the  
suburbs, or out on your favorite patch of  
country land—is directly competitive with  
today’s “standard” (and rather sleazy)  
wooden-framed dwellings!

TJ	Aspen Energy Forum, 4th, Aspen Institute for	
R10	Humanistic Studies, 1977.	
.A79	Solar architecture : proceedings of the	
1977	Aspen Energy Forum 1977, May 27, 28, and 29.	
	Aspen, Colorado / editors, Gregory	
	E. Fanta, Kenneth R. Olson ; graphics, T.	
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## ENERGY PERFORMANCE OF SOLAR WALLS: A COMPUTER ANALYSIS

Francisco Arumi and Mo Hourmanesh  
Energy and Buildings

Vol. 1, no. 2, October 1977,

p. 167-174.

This paper illustrates how the computer model for the Dynamic Energy Response Of Buildings (DEROB) can be used successfully to model the performance of passive solar systems when integrated into a specific structure, and it also suggests possible variations of the Trombe Michael wall for its adaptation in climates like the one in Central Texas. DEROB is a fully dynamic research program that has been in operation since 1973 and it includes full thermal coupling among the constituent rooms of a building as well as a spectroscopic analysis of glass. This capability permits the direct use of the program for the analysis of solar walls by treating the space between the glass and the absorbing surface as a chamber thermally coupled to the occupied space via the heat storage "chamber" in the wall and operable air ducts. Various wall configurations are analyzed and classified according to their net annual performance.

## Solar Heating & Cooling, v.2, no.5, Oct.1977, p.

8	Seniors' Water Solar Heated in Pioneer Institutional Application
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Paul, J. K.  
Solar heating and cooling : recent  
advances / J. K. Paul. -- Park Ridge, N.J.  
: Noyes Data Corp., c1977.  
- x, 485 p. : ill. : 24 cm. (Energy  
technology review ; no. 16)

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# **SIMULATION ANALYSIS OF PASSIVE SOLAR HEATED BUILDINGS - PRELIMINARY RESULTS**

J. D. Balcomb, J. C. Hedstrom and R. D.  
McFarland

Solar Energy, vol. 19, no. 3, 1977, p. 277-  
282

**Abstract**—Solar gains through windows, walls, modified walls, skylights, clerestory windows, and roof sections provide an opportunity to dramatically reduce the total heating energy requirements of a building. Many such passive solar heating elements are currently available to a designer presenting a large number of possible system designs. A computer simulation analysis has been employed to aid in the selection of components. The results indicate that a performance comparable to that of a conventional active solar heating system should be achievable in an optimized design passive solar heating system. The placement and type of thermal storage is crucial to good performance. Movable insulation of the window increases the performance. When used in conjunction with a conventional heating system, temperature variations in the building can be reduced to those normally experienced.

## **Technical Note - THE ARCHITECTURE OF A PASSIVE SYSTEM OF DIURNAL RADIATION HEATING AND COOLING**

Kenneth L. Haggard

Solar Energy, vol. 19, no. 4, 1977, p. 403 - 406

### **THE ATASCADERO PROTOTYPE**

At California Polytechnic State University, a 2 yr evaluation of such a passive system has been carried out with funds from HUD. This system, developed by Mr. Harold Hay, operates on the same principles as most vernacular buildings found in the hot-dry climates of the world, using high heat capacity to moderate diurnal extremes of temperature. Use of modern plastics to contain water and create movable insulation allows the use of diurnal radiations (incoming solar radiation for heating and nightsky out-radiation for cooling) to maintain a moderate temperature. This flexible system plus modern electronic controls allow for a more effective and efficient operation than that of the traditional adobes and heavy masonry buildings typical of hot-dry climates.

**THE BEALE SOLAR-HEATED SUBTERRANEAN GUEST HOUSE.**  
The Mother Earth News, no. 45, May/June 1977,  
p. 81-82.

Imagine a solar-heated cottage with no collectors, no pumps, no storage tanks, no thermostats, no heat exchangers ... none of the trappings of conventional "active" solar heating installations. Then imagine that same dwelling recessed into the side of a hill ... and you've got a pretty good idea of what William T. Beale's \$8,000 solar-heated guest house is all about.

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1977

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Canadian Congress of Applied Mechanics,  
6th, University of British Columbia, 1977.  
- CANCAM 77 ; proceedings = Comptes rendus  
/ v. J. Modi, editor. -- [s.l. : s.n.,  
1977?]  
2 v. (xli, 1051 p.) : ill. : 28 cm.  
Held May 30 to June 3, 1977.

**Passive Solar Heating in a Northern Climate**  
R. R. Gilpin . . . 837

## SOLAR HEATING AND NIGHT RADIATION COOLING BY A ROOF RADIATION TRAP

B. Givoni

Energy and Buildings

Vol. 1, no. 2, October 1977,

p. 141-146.

*The paper describes a new system, the Roof Radiation Trap, which utilizes solar energy for heating of buildings in winter and nocturnal radiation for cooling in summer. The radiation trap consists of fixed insulating layer separated from the flat roof and glazing, protected by hinged insulating panel, in the southern gap between the roof and the fixed insulation. This fixed insulating layer is covered by corrugated metal sheets, painted white, which serve as nocturnal radiators in summer.*

*The radiation trap is integrated with the building, thermally as well as architecturally. In winter the sun energy penetrates through the glazing and is absorbed directly in the roof, which serves as a combined collector, storage for one night and heat distribution system.*

*The hot air in the space between the flat roof and the fixed insulation is blown into a thermal storage of gravel, under the floor or inside the building. The stored heat is "recovered" by forced convection during cloudy days.*

## SOLAR BATTERY FOR PASSIVE HEATING

Edward Moran

Popular Science, vol. 210, no. 6, June 1977,  
page 94

## SOLAR SPACE HEATING.

W. Hurrele.

Alternative Sources of Energy, no.27, Aug.1977,  
p.11-13.

Passive solar systems extend the thought patterns of conservation to sophisticated elegance in order to keep the hardware and technology simple. Felix Trombe, director of the Centre National de la Recherche Scientifique in Odeillo, France, is usually mentioned in discussions of passive systems. The Centre's nine-story building is solar assisted by

thermosyphoning collectors that are part of the wall structure. Heat is stored by the thermal mass of the concrete floors/ceilings. The only moving parts are dampers. Three homes using his ideas have been built there, too. Odeillo is at 43 degrees north in the Pyrenees and has beautiful sunshine.

Power sources,  
Solar - Heating  
& cooling

CN-142,792

## DESIGN MANUAL FOR SOLAR WATER HEATERS

(No. 201) \$5.00

"the only place I've seen some of the necessary calculations" - J. Baldwin, The Coevolution Quarterly (the ongoing Whole Earth Catalog)

1977

This definitive manual is based on years of experience by a practicing solar design group. It includes a step by step procedure for selecting the optimum collector and storage tank, computing the fuel savings, and finding the system's rate of return for both constant and increasing fuel rates. To aid those not familiar with solar water heating, the manual contains introductory material and wiring-plumbing diagrams for a complete range of systems. Profusely illustrated, with many worked out examples, it will allow the engineer to professionally design solar water heaters. 40 Pages

# SOLAR ENERGY AND ECONOMIC CONSIDERATIONS.

J.F. MILLER.

ASHRAE J., Nov.1977, p.40-

*The energy crisis has made it necessary to compare energy demands—present and future—with available, finite resources, and to discover new non-depletable resources, such as solar and wind energy. The HVAC industry has the capability to reduce the amount of energy its products consume by as much as 50%, by making conservation and finance the controlling factors in system design. By thinking in terms of Btu's per dollar, owners, architects,engineers and contractors can provide the most desired result: A system (solar or non-solar) that saves both financial investment and finite energy resources. This article is based on a presentation by the author at a Seminar, 'The Economics of Solar Energy, held during ASHRAE's 1977 Annual Meeting in Halifax, NS, Canada.*

# SUPPOSE YOU WERE GIVEN THE CHARIOT OF THE SUN.

F.J. Fisher.

Exxon USA, 2nd quarter, 1977, p.18-21.

"What would you do?" asks the American Institute of architects Research Corp. in a national contest supported by a grant-in-aid from EXXon.

ASHRAE Journal, v.19, no.11

Nov.  
1977

# SOLAR TECHNOLOGY: UPDATE "77.

J.F. Miller

SOLAR ENERGY AND ECONOMIC CONSIDERATIONS, p.40-42

*The energy crisis has made it necessary to compare energy demands—present and future—with available, finite resources, and to discover new non-depletable resources, such as solar and wind energy. The HVAC industry has the capability to reduce the amount of energy its products consume by as much as 50%, by making conservation and finance the controlling factors in system design. By thinking in terms of Btu's per dollar, owners, architects,engineers and contractors can provide the most desired result: A system (solar or non-solar) that saves both financial investment and finite energy resources. This article is based on a presentation by the author at a Seminar, 'The Economics of Solar Energy, held during ASHRAE's 1977 Annual Meeting in Halifax, NS, Canada.*

NA Davis, Albert J.

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# MODELLING OF A SOLAR-OPERATED ABSORPTION AIR CONDITIONER SYSTEM WITH REFRIGERANT STORAGE.

Stuart L. Grassie and Norman R. Sheridan.

Solar Energy.

Vol. 19 no. 6

1977

p.691-700.

**Abstract**—A detailed dynamic model of a solar air conditioning system is reported. The model, including the solar collector and cooling tower, is described in terms of design parameters. Ambient wet and dry bulb temperatures and solar radiation are the required inputs. System temperatures, energy flows and coefficient of performance can be predicted. Careful attention is given to the evaporator model and the control of refrigerant flow. Typical performance results are discussed. Finally several recommendations for future investigations are made.

ASHRAE Journal, v.19, no.11

Nov.  
1977

**SOLAR TECHNOLOGY: UPDATE '77.**

SELF-SUPPORTING ACTIVE SOLAR ENERGY SYSTEM  
R. Zakhariya  
pp.60-63

*Introducing a new type of solar collector and a new type of solar energy total system for which patents have been applied for by the author.*

ASHRAE Journal, v.19, no.11

Nov.  
1977

**SOLAR TECHNOLOGY: UPDATE '77.**

SOLAR ABSORPTION SYSTEM FOR SPACE COOLING & HEATING  
I. Shwarts and A. Shitzer, p. 51-54.

*Space heating and cooling are probably among the most promising ways for solar energy utilization in the near future. The purpose of the present study is to investigate the feasibility of operating the solar absorption system for space cooling and as a heat pump for space heating. Such an approach permits the year-round utilization of the rather expensive system of solar collectors which has to be installed in any case. The thermodynamic analysis is performed for various ranges of the operation parameters selected to conform to typical Israeli climatic conditions. A number of systems have been considered. The results indicate that the H<sub>2</sub>O-LiBr heat pump system may provide considerable energy savings in year-round air conditioning application.*

**THIS \$30 SOLAR SETUP HEATS A 30 X 40 WORKSHOP FOR FIVE HOURS OR MORE EVERY SUNNY WINTER DAY.**

Don R. & George Waterman  
The Mother Earth News, No. 48, November/  
December 1977, p. 125-127.

*We accomplished this feat with a four-fold secret of low-cost construction: [1] We glazed our 8' X 30' solar collector with inexpensive plastic film instead of glass or plexiglass, [2] we used our workshop's existing south-facing wall for the back of the collector, [3] we did not build any heat storage into our design, and [4] we scrounged a great deal of the material that went into the solar heating system.*

ASHRAE Journal, v.19, no.11

Nov.  
1977

**SOLAR TECHNOLOGY: UPDATE '77.**

SOLAR ENERGY AND LARGE BUILDING HVAC SYSTEMS:  
ARE THEY COMPATIBLE?  
Milton Meckler  
pp.43-50

*A well planned building designed with energy conservation in mind goes hand in hand with the basic energy requirements essential for compatible solar heating and cooling systems. This article is based on a Seminar presentation by the author during ASHRAE's 1977 Annual Meeting in Halifax, N.S., Canada.*

**SENSOR LOCATIONS IN SOLAR SYSTEMS.**

R. Lewis, Jr. and J.B. Carr.  
Solar Heating & Cooling, Dec.1977, p.21-23.

The proper location of sensors is vital to the performance of any solar heating system.

**OPTIMAL SIZING OF SOLAR HEATING COMPONENTS BY EQUATING MARGINAL COSTS OF SUBOPTIMAL INVESTMENT PATHS.**

Robert L. Nichols  
Solar Energy  
Vol. 19 no 6  
p.747-750  
1977.

*This paper illustrates a design method for the optimal sizing of building insulation components, solar collector, and solar heat storage device for a building heated with fuel and with solar energy in order to minimize the sum of first and operating costs. Given the input data, optimum investment levels in each of the system components are computed in one iteration. The technique differs in this respect from currently used thermal design methods, such as the York Energy Saver computer program, in which the designer uses an iterative process to analyze the incremental costs due to one-at-a-time changes in the design variables in order to home in on an optimal solution[1].*

Power sources, Solar - Heating & cooling

AIR CONDITIONING AND HEATING WITH SOLAR POWER.  
Solar Heating & Cooling, Dec.1977, p.10-13.

Solar powered residential air conditioning  
is no longer an inventor's dream.

The proof is in Evansville, Indiana.

**QD Electrochemical Society.**

552 Extended abstracts, v. 77-1. Spring  
.E42 meeting, Philadelphia, Pennsylvania, May 8-  
1977 13, 1977. -- Princeton, N.J. : Electro-  
v.77-1 chemical Society, c1977.

1027 p. : ill. ; 22 cm.

MATERIALS AND PROCESSES FOR SOLAR HEATING  
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**Intersociety Energy Conversion Engineering  
Conference, 12th, Washington, 1977.**

Proceedings of the 12th Intersociety  
Energy Conversion Engineering Conference,  
Washington, D. C., August 2<sup>nd</sup> through  
September 2, 1977. — La Grange, Ill. :

779206 — Stimulation of the Solar Industry by Way  
of the Federal Buildings Program, L. A. Alex-  
ander, F. A. Costello, *InterTechnology/Solar  
Corp.*, Warrenton, Va. .... 1250

779209 — The Page-Jackson Elementary School  
Solar Heating and Cooling System, F. A. Cos- 2)  
tello, A. K. Jain, S. Kumar, H. S. Liers, W.  
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ton, Va. .... 1255

779211 — A Plastic Solar Panel, Heat Storage,  
Baseboard Heating System for Both Swimming  
Pool and Home, T. R. Galloway, *Lawrence Liv-  
ermore Lab.*, Livermore, Calif. .... 1261

**ERDA Facilities Solar Design Handbook.**

Energy Research and Development Administration,  
Washington, D.C. Aug 77. 178p

ERDA-77-65 Price code: PC A09/MF A01

This handbook covers design of solar heating systems for  
commercial and laboratory buildings at Energy Research  
and Development Facilities. It includes discussions of solar  
energy fundamentals, solar heating and cooling technolo-  
gy, systems, and components, as well as a discussion of  
solar-system economics. Quantitative analysis, with  
generalized design and sizing curves, is presented for solar  
heating so that collector and other system parameters can  
be cost-economically sized without a computer simulation.  
Solar-system design considerations and guidelines, as well  
as guidelines for developing subsystem specifications, are  
presented. Thus, this handbook is both a primer for the  
solar novice and a reference manual for the solar-system  
designer. (ERA citation 03.011927)

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**Society of Engineering Science.**

Recent advances in engineering sciences;  
proceedings of the 14th annual meeting of  
the Society of Engineering Science, Inc. /  
edited by G. C. Sih. -- Bethlehem, Pa. :  
Lehigh University, c1977.

Held November 14-16, 1977 at Bethlehem.  
Includes bibliographical references and  
index.

I. Engineering--Congresses. I. Lehigh  
University, Bethlehem, Pa. II.  
Title.

Solar heating and air conditioning for the Southwestern United  
States  
by G. Darkazalli and T. J. Lawley

1327

**COEFFICIENT OF PERFORMANCE FOR SOLAR-POWERED  
SPACE COOLING SYSTEMS**

H. M. Curran  
Solar Energy

Vol. 19, no. 5, 1977

P. 601-603. Various types of systems utilizing solar energy for space cooling  
are currently in the R&D stage. Unfortunately, performance  
comparisons of computed or experimental results for the  
different systems are rendered difficult by lack of uniformity in  
the bases used for defining coefficient of performance.

The objective of this technical note is to propose a common  
basis for defining coefficient of performance (COP) for diverse  
cooling systems which are wholly or partially driven by solar  
energy. Such a common basis would permit more meaningful  
comparisons between different systems.

**SOLAR AIR-CONDITIONING PERFORMANCE USING  
STOCHASTIC WEATHER MODELS**

D.K. Anand, R.W. Allen, and E.O. Bazques  
J. Energy

Vol. 1, no. 5, Sept.- Oct. 1977,  
p. 319-323.

CN-142,668, v.1-3

1977

**AN INVESTIGATION OF METHODS TO IMPROVE HEAT PUMP  
PERFORMANCE AND RELIABILITY IN A NORTHERN CLIMATE.  
VOLUME 1, VOLUME 2: APPENDIX A, VOLUME 3: APPENDICES  
B,C,D. (Final Rpt. Research Proj.544-1). Jan.  
1977.**

Electric Power Research Inst.,  
Palo Alto, Calif.

EPRI EM-319  
v.1-3

Westinghouse Electric Corp.,  
Pittsburgh, Penn.

**Heat pumps**

**Power sources, Solar - Heating & cooling**

CN-142,793

1977

**ILLUSTRATED SOLAR ENERGY GUIDE. 23p. 1977.**

Horizon Industries,  
North Hollywood, Calif.

**Power sources, Solar  
Solar collectors**

**Power sources, Solar - Heating & cooling**

TJ

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Energy development III / sponsored by the IEEE  
Energy Development Subcommittee of the IEEE  
Power Generation Committee of the IEEE Power  
Engineering Society. -- New York : Institute  
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c1977.

178 p. : ill. ; 28 cm. -- (IEEE Power  
Engineering Society Papers ; 3)

"77CH1215-3-PWR"

Solar Energy and Domestic Heating Needs - A French Project APAMH and  
LE HAVRE, by M.F. Simon and H. Michel.....P.142....

# RESIDENCE SPACE HEATING & COOLING POOL HEATING. M.T. Raiford.

Solar Heating & Cooling, Oct.1977, p.30.

Solar-assisted heat pump system using the pool for storage at home, and at the same time to begin establishing himself as a dealer/installer of solar heating systems.

23  
163.2  
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1977  
Greater Los Angeles Area Energy Symposium,  
1977.  
Greater Los Angeles Area Energy Symposium  
... c1977. (Card 3)

1. Power resources--Congresses. I. Robinson, John W., ed. II. Los Angeles Council of Engineers and Scientists. III. American Nuclear Society. Los Angeles Section. IV. Title: Q# E 3: Quality of life = energy x economics x environment.

Analysis of Utility Demand in the Presence of Widespread Use  
of Solar Heating Systems  
B. J. Johnson, Aerospace Corporation

# SOLAR ENERGY AND THE STEAM RANKINE CYCLE FOR DRIVING AND ASSISTING HEAT PUMPS IN HEATING AND COOLING MODES.

Noam Lior

Energy Conversion, 1977, vol. 16, no. 3,  
p. 111-123

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OF POOR QUALITY

# A LARGE SOLAR HEATING SYSTEM FOR A SAUDI CAMPUS COMPLEX.

J.R. Schneider and S.F. Glover.

Building Systems Design, v.74, no.5, Aug./Sept.1977,  
p.29-43.

The design program is presented describing the world's largest central solar heating system developed for the Saudi Arabian Government. Domestic hot water and building space heating is provided for a campus complex of fourteen buildings. Feasibility studies through the final design are discussed.

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.P37  
Paul, J. K.  
Solar heating and cooling : recent  
advances / J. K. Paul. -- Park Ridge, N.J.  
: Mayer Data Corp., c1977.  
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# Technical Note - LESSONS LEARNED FROM ATLANTA (TOWNS) SOLAR EXPERIMENT

A. Weinstein, R. T. Duncan, Jr., and W. C. Sherbin

Solar Energy, vol. 19, no. 4, 1977, p. 421 - 427

Construction of the solar system began in April 1975 and the system was dedicated on 26 November 1975. Fig. 1 is a photograph of the installed collectors. After a period of system debugging and shakedown, performance data monitoring was begun on 1 February 1976. This paper is an interim report on the problems encountered and performance test results of the solar heating mode. When results on solar cooling become available they will be reported in a subsequent paper.

Alternative Sources of Energy, no.26, June 1977.

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810 Aspen Energy Forum, 4th, Aspen Institute for  
.A79 Humanistic Studies, 1977.  
1977 Solar architecture : proceedings of the  
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29, 1977, Aspen, Colorado / editors, Gregory

## ACTIVE SYSTEMS

SOLAR COLLECTOR SIZING . . . . . 149  
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RESIDENTIAL APPLICATIONS OF HYBRID SOLAR THERMAL/  
SOLAR PHOTOVOLTAIC ENERGY CONVERSION  
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Pittsburgh Conference on Modeling and Simula-  
tion, 7th, University of Pittsburgh, 1976.  
Modeling and simulation. v. 7, pt. 1 & 2.  
Proceedings of the seventh annual Pittsburgh  
Conference, held April 26-27, 1976, Uni-  
versity of Pittsburgh / edited by William G.  
Vogt, Marlin H. Mickle. -- Pittsburgh :  
Instrumentation Society of America, c1976.

## SOLAR ENERGY SYSTEMS-II

Session Organizer and Chairman: Raymond P. Voith, University of Toledo

A SOLAR HEATING SYSTEM SIMULATION MODEL, Adel H. Eltimsahy and  
Clifford H. Copass, The University of Toledo p.1092

A COMPUTER SYSTEM FOR A SOLAR HEATING RESEARCH STATION, Adel H.  
Eltimsahy, Clifford H. Copass and Raymond P. Voith, University of Toledo p.1098

EXPERIMENTAL SOLAR HEATING-COOLING SYSTEM MODEL TESTS OF A  
FULL-SCALE BUILDING SYSTEM, David Namkoong, NASA, Lewis Research  
Center p.1103

OPTIMIZATION OF ENERGY USAGE IN ELECTRICALLY HEATED HOMES,  
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POWERED AIR CONDITIONING SYSTEM, D. K. Anand, E. O. Bazques and R. W.  
Allen, University of Maryland p.1121

COMPUTER MODEL OF A SOLAR-ASSISTED HEATING AND COOLING DESIGN  
APPROACH IMPLEMENTED ON A MINICOMPUTER INSTALLATION, Ronald L.  
Krutz and Richard Dipolito, Carnegie-Mellon University p.31

TJ  
163.2  
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RR

Perspectives on the energy crisis : technical,  
regulatory, environmental, economic, pro-  
spective. / advisory editors, Howard Gordon,  
Roy Meador. -- Ann Arbor, Mich. : Ann Arbor  
Science Publishers, c1977.  
2 v. : ill. ; 29 cm.  
Includes bibliographies and index.

THE WORLD'S LARGEST SOLAR-HEATED  
BUILDING . . . . . 187

(News Report from Solar Heating & Cooling, April 1977)

The structure is at the Shenandoah Solar Recreation Center and has been con-  
structed through an ERDA grant to the Georgia Institute of Technology. The  
work of J. Richard Williams, Project Director, and his associates is described.  
Dr. Williams explains why effective use of solar collectors must involve conser-  
vation oriented designs rather than simply attaching them to conventional  
energy-inefficient structures. This ambitious project shows how the application  
of known technology from the start of a building project can make solar energy  
work to optimum effect.



**N78-12536/** Decisions and Designs, Inc., McLean, Va.  
**AN ATTITUDINAL STUDY OF THE HOME MARKET FOR SOLAR DEVICES** Progress Report, Mar. - Sep. 1977  
 Vincent N. Campbell, Rex V. Brown, Thomas R. Rhees, and Dominic J. Repici Sep. 1977 73 p refs  
 (Contract N00014-75-C-0426)  
 (AD-A045082; TR-77-5-25) Avail: NTIS HC A04/MF A01 CSCI 13/1

This study estimates that 1.1 million American residences would have home and hot water heated with solar energy by 1985 if the total cost averaged \$20 a month more than the cost of heating with fossil fuels, and initial costs were no barrier. An additional 7.2 million homes would have hot water alone heated with solar energy by 1985 if the total cost was \$5 a month more. These are fairly favorable cost assumptions under current conditions. Almost half (44%) of potential homeowners surveyed would prefer to have their living spaces and hot water heated with solar energy if the total cost averaged \$20 per month more than conventional heating and initial costs were no barrier. Although interest runs high, for various economic and technical reasons only about 1 in 75 American families may have both their home and water heated with solar energy by 1985. Any development that makes solar energy cost-competitive with fossil fuels for home heating will increase the level of market penetration. Another key to how quickly Americans will have solar homes is how fast builders and developers use solar energy in new homes and can assure good performance.

Author (GRA)

**SOLAR HEATING IMPACT ON REVENUE SHOULD BE SMALL.** Electr. Light Power (Boston); 55: No. 2, 22-23 (Feb 1977).

At a recent Pennsylvania Electric Association meeting, Harold Lorsch (Franklin Institute) said solar-assisted residential space heating probably will not disrupt revenues of public utilities in this century. The Franklin Institute study concentrated on the effect of solar heat and hot water systems with electrical backups in single-family homes. Two locations were modeled: one in Allentown and the other in Philadelphia, Pa. In general, the study conclusions show that the solar-assisted alternatives have an adverse impact on utility revenue, but due to the sluggish growth of solar systems predicted, the overall effect is expected to be minimal. The study assumes that solar-assisted heating systems will account for only five to ten percent of the electrical heat market (for single-family homes) by the year 2000. A key reason for this slow growth, the study shows, is the extra cost of solar energy to the homeowner who must borrow the capital needed over 20 years at an eight percent interest rate. (MCW)

TA  
 168  
 .I52  
 1977

**International Conference on Cybernetics and Society, Washington, D.C., 1977.**

**Energy Conservation by Adaptive Control for a Solar Heated Building,** Donald R. Farris, T. E. McDonald, T. E. Springer, and Hugh S. Murray, Los Alamos Scientific Labs and James L. Melsa,

**University of Notre Dame** 329

Identification and optimal control techniques are combined to form an adaptive optimal control strategy which is used to minimize the auxiliary energy consumption for a solar heated building. The adaptive optimal control strategy is described and application of the adaptive optimal controller to the heating, ventilating, and air conditioning (HVAC) system in an appropriate building is modeled. The building used is the newly completed National Security and Resources Study Center (NSRSC) at the Los Alamos Scientific Laboratory (LASL). The NSRSC uses an 8000 sq. ft. solar collector to provide energy for heating and cooling the building. A cost functional to define optimal performance of the HVAC system and an identification process to produce a linearized building model are combined to yield an adaptive linear regulator solution. Although solar energy is used for both heating and cooling the NSRSC, only the results from the heating simulation are available for presentation here. Energy savings predicted by the model when compared to a conventional control system are described and an alternate system configuration is briefly discussed. Plans for actual implementation of the adaptive optimal controller are discussed.

TJ  
 R10  
 .I55

**International Solar Energy Society. UK Section**

**Economic & commercial assessment of solar energy conversion : conference (C12) at the Royal Institution July 1977. — London : UK - ISES, c1977.**

98 p. : ill. ; 30 cm.

Includes bibliographical references.

1. Solar energy—Congresses.

I. Title.

**The Value of Solar Heating**

A.H. LANCASHIRE and K.R. WILLIAMS p. 10

**Solar Water Heating - Some Economic and Commercial Aspects**

B. MCNELIS p. 54

**Projected Market Penetration of Solar Heating and Cooling in the United States**

749 P.C. SPEWAK p. 78

**EXPERIMENTAL STUDY ON HOUSE COOLING AND HEATING WITH SOLAR ENERGY USING FLAT PLATE COLLECTOR.**

Nobuo Nakahara, Yasuyuki Miyakawa and Mitsunobu Yamamoto.

Solar Energy.

Vol. 19 no. 6

1977

p. 657-662.

**Abstract**—The OSE Project aims at developing the technology to utilize solar energy for heating, cooling and hot water supply on the basis of various technology for energy conservation in buildings. For the first step of this project a solar heating and cooling system with flat plate collectors and absorption refrigeration machine was installed in a house in 1974. This paper reports outlines of the system and operating results.

**ON THE STUDY OF APPLICATIONS OF SOLAR THERMAL ENERGY FOR MOBILE HOMES**

J. P. Chiou

Solar Energy

Vol. 19, no. 5, 1977,

p. 449-446.

**Abstract**—A great deal of work has been done in the study of applications of solar thermal energy for conventional site-built houses; however, little effort has been directed to the study of these applications for mobile homes although they account virtually for a large portion of low cost single family homes. Mobile homes are different from the conventional home and building in configuration, structure, arrangement and cost. The concept and criteria of designing a solar space heating/cooling system for mobile homes differs somewhat from that of a conventional region with Tennessee's climate and geographic latitude. The economics of solar systems are considered for typical site-built house or building. The mobile home is a low-cost housing. The solar system developed for mobile homes, cities across the state representing different weather conditions. Financing is considered for conditions likely to be characteristics of mobile homes and their impacts on the design/selection of its solar space heating/cooling system; graphs presented to aid in economic decisions.

**TECHNICAL NOTE -- SIMULATION STUDY OF SEVERAL SOLAR HEATING SYSTEMS WITH OFFPEAK AUXILIARY**

P. J. Hughes, J. A. Duffie and W. A. Beckman

Solar Energy, vol. 19, no. 3, 1977, p. 317

- 319

In this paper, several offpeak auxiliary solar air heating systems are compared, using simulation methods to determine the best ways of incorporating on-site thermal storage of energy supplied by a utility.

**N78-12651/ Florida Solar Energy Center, Cape Canaveral. 14 77  
SOLAR ENERGY COMMERCIALIZATION AT THE STATE  
LEVEL: THE FLORIDA SOLAR ENERGY WATER HEATER  
PROGRAM**

Milan Johnson and Thomas F. Tiedemann Mar 1977 142 p  
ref

(Contract FEA-CA-05-50053-00)

(PB-270158/9, FSEC-76-3: FEA/G-77/270) Avail: NTIS  
HC A07/MF A01 CSCL 10A

A detailed study was made of current problems associated with the introduction of commercialization of solar technologies in the state of Florida--particularly domestic water heating. Solar energy-related legislation considered by state legislatures is analyzed, with emphasis on actions recommended to accelerate commercialization and use. The study presents proposed standards and programs consistent with suggested comprehensive Florida solar energy commercialization plans. The use of solar water heaters in state buildings as a potential incentive to a local solar energy industry is briefly examined. Included are detailed instructions for constructing a model solar water heater, directed primarily at high school students; and climatological data. GRA

**ECONOMICS OF SOLAR HEATING WITH HOMEOWNER-TYPE FINANCING**

R.L. Reid, E. Lumsdaine, and L. Albrecht  
Solar Energy

Vol. 19, no. 5, 1977,

p. 513-517.

**Abstract**—A feasibility study of the present-day economics of solar space and hot water heating is presented for a typical region with Tennessee's climate and geographic latitude. The economics of solar systems are considered for typical site-built house or building. The mobile home is a low-cost housing. The solar system developed for mobile homes, cities across the state representing different weather conditions. Financing is considered for conditions likely to be characteristics of mobile homes and their impacts on the design/selection of its solar space heating/cooling system; graphs presented to aid in economic decisions.

**N77-31883/ Joint Economic Committee (U. S. Congress).**

**THE ECONOMICS OF SOLAR HOME HEATING**

William D. Schulze (New Mexico Univ.) Washington GPO 1977

80 p ref Study for Joint Economic Comm., 95th Congr.,  
1st Sess., 13 Mar. 1977

(GPO-85-329) Avail: SOD HC \$1.35

The feasibility of residential use of solar energy is presented. Its extensive application as a result of energy price decontrols or in areas of natural gas shortages is discussed. The economic incentive for solar energy conversion through low interest loans is outlined. G.D.H.

A79-34013 An economic comparison between solar and conventional residential air conditioning in Miami, Florida. B. H. Rotofante (Miami, University, Coral Gables, Fla.). In: Alternative energy sources: Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 2. (A79-34002 13-44) Washington, D.C., Hemisphere Publishing Corp. 1978, p. 749-759. 6 refs.

- TA Institute of Environmental Sciences.  
1 Environmental technology '77: proceedings.  
.I39913 -- Mt. Prospect, Ill. : The Institute, c1977.  
1977 xviii, 437 p.  
23rd annual technical meeting held in Los Angeles, Calif. April 25-27, 1977.  
ISBN 0-915414-17-1  
1. Environmental testing. 2.  
Environmental engineering--Societies, etc.  
T M1+10

NMSU - CASA DEL SOL OF THE FUTURE  
By H. L. Horak and Dr. R. L. San Martin

- TJ Aspen Energy Forum, 4th, Aspen Institute for  
810 Humanistic Studies, 1977.  
.A79 Solar architecture : proceedings of the  
1977 Aspen Energy Forum 1977, May 27, 28, and 29, 1977, Aspen, Colorado / editors, Gregory E. Franta, Kenneth R. Olson ; graphics, T. Michael Manchester. -- Ann Arbor, Mich. : Ann Arbor Science Publishers, c1978.

- THE ROARING FORK RESOURCE CENTER . . . . . 287  
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Paul Rubin and John Katzenberger  
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- ARCHITECTURE, THE SUN, AND THE ROARING FORK  
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Gregory Franta, AIA  
PROJECTS IN TELLURIDE . . . . . 189  
Dean Randle  
THE COMMUNITY COLLEGE OF DENVER AND OTHER  
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John Anderson

THE SUN BLEST HOUSE: AN ENERGY CONSERVATIVE, ADOBE  
BRICK SOLAR HOME.  
Bill and Wanda Colyer.  
Alternative Sources of Energy, no.29, Dec.1977,  
p.29-34.

The purpose of building the Sun Blest House was to provide a comfortable energy conservative home using only renewable energy sources -- solar heat, primarily, and wood heat for back-up. The architectural design approach was to provide a southwest solar farm house. The objectives included building a home with small temperature extremes, and constructed with readily available native materials using simple and conventional building techniques wherever possible.

CI-142,790  
NASA TECH HOUSE. 1977. 19p.

NASA,  
Washington, D.C.

EP-143

Buildings, Solar  
Buildings - NASA

Technical Note - LESSONS LEARNED FROM ATLANTA  
(TOWNS) SOLAR EXPERIMENT  
A. Weinstein, R. T. Duncan, Jr., and W. C. Sherbin

Solar Energy, vol. 19, no. 4, 1977, p. 421 - 427

Construction of the solar system began in April 1975 and the system was dedicated on 26 November 1975. Fig. 1 is a photograph of the installed collectors. After a period of system debugging and shakedown, performance data monitoring was begun on 1 February 1976. This paper is an interim report on the problems encountered and performance test results of the solar heating mode. When results on solar cooling become available they will be reported in a subsequent paper.

TH  
7413  
.C56

Chouard, Philippe

Bilan thermique d'une maison solaire :  
méthode de calcul rapide / Philippe Chouard,  
Henri Michel, Michel F. Simon. — Paris :  
Éditions Eyrolles, 1977.

164 p. : ill. — (Collection de la direc-  
tion des études et recherches d'électricité  
de France ISSN 0399-4198)

Includes index.

1. Solar houses. 2. Solar heating. I.  
Michel, Henri, joint author. II. Simon,  
Michel F. joint author. III. Title.  
III. Series. 697'.73

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Watson, Donald, 1937-

Designing & building a solar house /  
Donald Watson. Charlotte, Vt. :  
Garden Way Pub., 1977.

vi, 281 p. : ill. ; 29 cm. \$12.95.  
pbk. :\$6.95

Includes index. Bibliography: p.

1. Solar heating. 2. Solar houses --  
Design and construction. I. Title.  
697.78 76-53830 0-882660-86-1  
0-882660-85-3 76V26555

TJ  
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Chauliaguet, Charles

L'énergie solaire dans le bâtiment / par  
Charles Chauliaguet assisté de Pierre  
Baratsabal et Jean-Pierre Batellier. --  
Paris : Editions Eyrolles, cl977.

2020 p. : ill. ; 25 cm.

1. Solar energy. 2. Architecture and  
solar radiation. I. Baratsabal, Pierre.  
II. Batellier, Jean-Pierre. II. Title.  
621.47

TJ  
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Aspen Energy Forum, 4th, Aspen Institute for  
Humanistic Studies, 1977.

Solar architecture : proceedings of the  
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29, 1977, Aspen, Colorado / editors, Gregory  
E. Franta, Kenneth R. Olson ; graphics, T.  
Michael Manchester. — Ann Arbor, Mich. :  
Ann Arbor Science Publishers, cl978.

ix, 331 p. : ill. ; 24 cm.

Includes index.

TH  
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Solar dwelling design concepts. New  
York : Drake Publishers, 1977.

144 p. : ill. ; 22 x 28 cm. pbk.  
:\$6.95

1. Solar heating. 2. Solar houses --  
Design and construction.

728 77-6919 0-847315-74-6 77V31587

TJ  
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L43

Lee, Kalman

Encyclopedia of energy-efficient  
building design : 391 practical case  
studies / by Kalman Lee. Boston :  
[Environmental Design and Research  
Center], 1977.

2 v. (1023 p.) : ill. ; 27 cm.

Includes bibliographical references  
and indexes.

1. Buildings -- Energy conservation  
-- Case studies. I. Title.

TH  
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1977

Colorado. State University, Fort  
Collins. Solar Energy Applications  
Laboratory.

Solar heating and cooling of  
residential buildings : design of  
systems / prepared by Solar Energy  
applications Laboratory, Colorado  
State University. — [Washington] :  
U.S. Dept. of Commerce : for sale by  
the Supt. of Docs., U.S. Govt. Print.  
Off., 1977.

647 p. in various pagings : ill. ;  
28 cm.

TH Anderson, Bruce N  
7413 Solar energy: fundamentals in building  
A5 design / Bruce Anderson. -- New York :  
1977 McGraw-Hill, c1977.  
1x, 374 p. : ill. ; 25 cm.  
Bibliography: p. [359]-370.

Containing practical, nontechnical information on virtually every aspect of the collection of solar heat, this reference book covers good building design, passive uses of solar energy, complex solar HVAC systems and solar water heating. Reflecting the author's extensive experience in building design, general contracting, product development, systems engineering, consulting and social impact and utilization research, the volume compares the relative merits of various methods of solar collection. It shows professionals how to evaluate products and detect ineffective equipment. One section discusses methods of incorporating the collection of solar heat into the actual fabric of the building itself. A major theme is energy conserving design, including weather and insulating values of materials. In addition, the book features a step-by-step process for determining the output of solar collectors and their proper size for a given building.

Mech. Eng., v.99, no.11, Nov.1977.

38 SOLAR HEATING IN NORTH AMERICA .....  
..... J. A. Duffie, W. A. Beckman, and J. G. Dekker  
The f-chart design method is used to evaluate annual dollar savings, the collector area, and the fuel savings for an optimized solar energy heating system in 87 locations in North America.

A DESIGN PROCEDURE FOR SOLAR AIR HEATING SYSTEMS  
S. A. Klein, W. A. Beckman and J. A. Duffie  
Solar Energy  
Vol. 19, no. 5, 1977,  
p. 509-512.

Abstract—A natural extension of the design procedure for liquid-based solar space and water heating systems is a similar analysis for solar heating systems using air as the heat transfer fluid. In this paper, a solar air heating system incorporating a flat-plate air heater and packed bed thermal storage is described and a simulation model for the system is developed. The results of many simulations of the air heating system are used to establish the relationship between system performance and the system design and meteorological variables. The results are presented in analytic and graphical form, referred to as an f chart for solar air heating systems. The results of simulations in several widely different climates suggest that the information presented in the f chart is location independent.

#### SOLAR HEATING AND COOLING.

J.A. Duffie.

ISA Trans., v.15, 1976, p.301-5.

Solar energy is discussed as an energy resource that can be converted into useful energy forms to meet a variety of energy needs. The review briefly explains the nature of this energy resource, the kinds of applications that can be made useful, and the status of several systems to which it has been applied. More specifically, information on solar collectors, solar water heating, solar heating of buildings, solar cooling plus other applications, are included.

TJ Perspectives on the energy crisis : technical,  
163.2 regulatory, environmental, economic, pro-  
P4P spective. / advisory editors, Howard Gordon,  
Roy Meador. — Ann Arbor, Mich. : Ann Arbor  
Science Publishers, c1977.  
2 v. : ill. ; 29 cm.

#### APPLICATIONS OF SOLAR ENERGY FOR HEATING AND COOLING OF BUILDINGS . . . . . 197

(By Richard C. Jordan and Benjamin Y. H. Liu, University of Minnesota. From a publication of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.)

A detailed survey is given in remarkably compact format of the centuries long history of solar energy applications. From 1615 to the present, principal events in the development of solar energy technology are covered. Specific applications of solar energy to space heating and cooling are historically detailed from "Scotty's Castle" (1929) to contemporary solar residences. This paper convincingly demonstrates that solar awareness and utilization are not new, but part of a continuing process of development.

TH 7413 .157 1977 International Telephone and Telegraph Corporation. Fluid Handling Division. Solar heating systems design manual [Morton Grove, Ill.] : Fluid Handling Division, Training & Education Dept., International Telephone and Telegraph Corp., 1977.

130 p. in various pagings : ill. ; 28 cm. \$2.50  
The Building Heat Loss Calculation

p. 1-1

Availability of Solar Energy

p. 2-1

Solar Energy Collectors

p. 3-1

Systems

p. 4-1

Solar System Design Examples

p. 5-1

ITT Bell & Gossett Solar Heating/  
Cooling System

p. 6-1

N78-30894/ Energy Research and Development Administration, Washington, D. C. Div. of Solar Energy  
ERDA FACILITIES SOLAR DESIGN HANDBOOK  
Aug. 1977 178 p. refs  
(ERDA-77-65) Avail: NTIS HC A09/MF A01

This handbook covers design of solar heating systems for commercial and laboratory buildings at Energy Research and Development Facilities. It includes discussions of solar energy fundamentals, solar heating and cooling technology, systems, and components, as well as a discussion of solar system economics. Quantitative analysis, with generalized design and sizing curves, is presented for solar heating so that collector and other system parameters can be cost economically sized without a computer simulation. Solar system design considerations and guidelines, as well as guidelines for developing subsystem specifications, are presented. Thus, this handbook is both a primer for the solar novice and a reference manual for the solar system designer.

ERA

## NASA-CP-2019

N77-30274/ National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala  
ERDA/NASA-MSFC SOLAR HEATING AND COOLING  
DEVELOPMENT AND DEMONSTRATION PROGRAM  
John M. Price In its Proc of the ASPE/MSFC Symp on Eng. and Productivity Gains from Space Technol May 1977 p 9-17  
(For primary document see N77-30273 21-31)  
Avail: NTIS HC A13/MF A01 CSCL 10A

## THE FORMAL IMPLICATION OF SOLAR RIGHTS

F. N. Arumi and R.L. Dodge

Energy and Buildings

Vol. 1, no. 2, October 1977,

p. 183-191.

A hand method to determine the vertical limits of construction when solar rights criteria are specified for neighboring structures is demonstrated and compared with a computer based method. The emphasis is placed on the methodology and it includes an appendix showing the logic and the listing of the computer programs.

## TRENDS: COMMERCIAL/INDUSTRIAL APPLICATIONS SPUR SOLAR DEVELOPMENT.

W.S. Comstock.

ASHRAE J., Nov. 1977, p. 32-

The solar system of the Frenchman's Reef--Holiday Inn will provide approximately 54% of the heat requirements for an average of 12 hours per day for one of the two 200-ton absorption chillers

TJ  
R10  
.C76  
1976

Crowther, Richard L.

Sun/Earth : how to use solar and climatic energies today / Richard Crowther. —  
Denver : Crowther/Solar Group, 1976.  
vii, 232 p. : ill. ; 20 x 32 cm.  
Includes bibliography and index.  
ISBN 0-918202-01-9

1. Solar energy. 2. Power resources.  
3. Buildings--Energy conservation. I.  
Title.

HT Pittsburgh Conference on Modeling and Simulation, 8th, University of Pittsburgh, 1977.  
 166 Modeling and simulation ... c1977.  
 .P5 Held April 21-22, 1977. University of  
 1977

SEASONAL STOCHASTIC SIMULATION EXPERIMENTS ON SOLAR AIR CONDITIONING  
 D. K. Anand, R. W. Allen and E. O. Bazques, University of Maryland. P. 459

Real weather data and stochastic weather models are used in simulating the performance of solar powered, air-cooled and water-cooled air conditioning systems for an entire cooling season. The simulations included various parametric models for the absorption machine and variation of collector area and mass flow rates. It is concluded that the stochastic data yield satisfactory results for various system configurations while permitting very inexpensive simulations.

A76-32803 Solar homes and sun heating. G. E. Daniels. New York, Harper and Row, Publishers, Inc., 1976. 185 p. \$8.95.

The use of solar energy to heat homes is discussed. The principles of solar heating are outlined, and fourteen types of solar-heating systems, including roof-reservoir sun heating, the Trombe-Michel solar wall, the Thomason system, thermosyphon water heaters, glass-vacuum heat collectors, and sun-tracking flat plate collectors, are described. The use of insulation to maximize heat retention and the adaptation of existing structures for solar heating are considered. Seasonal data on solar radiance for the U.S. are given. C.K.D.

TH 7413.B4

SOLAR HEATING DESIGN BY THE F-CHART METHOD. By William A. Beckman, Sanford A. Klein and John A. Duffie. 1977. John Wiley & Sons, 605 Third Ave., New York, NY 10016. 200 pp., bound, \$14.95.

This book provides a practical method for designing a solar heating system that relies partly on an auxiliary energy source. It considers all parts of the system and how best to utilize them. Chapters are self contained with introduction, references and examples. The contents include the following:

Description of solar heating systems which can be designed by the F-Chart Method; thermal performance of flat plate solar collectors; effects of collector orientation on the overall performance of solar heating systems; the F-Chart design procedure; calculation of heating loads; and how fuel and system costs data can be used to determine the economical optimum design. The appendices give climatic data, glossary, conversion tables for SI and English units, and a description of the F-Chart Method computer program.

TJ  
 810  
 .S61  
 1976

Solar Cooling and Heating Forum, Miami Beach, 1976.

Proceedings ... [1976?]

1. Solar energy--Congresses. 2. Architecture and solar radiation--Congresses. I. Veziroglu, T. Nejat, ed. II. United States. Energy Research and Development Administration. III. Title: Solar cooling and heating : a national forum.

ILLUSTRATED SOLAR  
 ENERGY GUIDE

(No. 102) \$3.00

An introduction to using solar energy for water and home heating. Begins with the simplest concepts and defines the words used in the field. Completely illustrated, with detailed descriptions of many different collectors and some simple systems, it is an excellent way to get started in solar. 23 Pages

HORIZON INDUSTRIES  
 12606 Burton Street  
 North Hollywood, CA 91605

TH  
 7413  
 .K73  
 1977

Kreider, Jan F., 1942-

Solar heating and cooling systems : engineering, practical design and economics / Jan F. Kreider and Frank Kreith. — Revised First Edition. — Washington : Hemisphere Pub. Corp., c1977.

ix, 342 p. : ill. ; 25 cm.

Designed as a how-to-do-it handbook, not a highly theoretical treatise, the book focuses its major attention on these areas:

conditioning.

- introductory information on solar and conventional energy use concepts and requirements
- fundamental principles of heat transfer and the nature of solar radiation
- practical and efficient methods of collecting solar energy
- detailed quantitative descriptions of the practical systems for heating or cooling by means of solar energy—with analyses of their economies

TH Wilbur, Paul J.  
7687.5 Solar cooling / Paul J. Wilbur and Susumu  
.W54 Karaki. — Philadelphia : Franklin Insti-  
tute Press, c1977.

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Rankine Cycle-Vapor Compression Refrigeration Systems .....	22
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Energy Storage .....	30
Heat Rejection .....	31
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Solar-powered cooling systems are discussed, with attention given to absorption refrigeration systems and Rankine cycle-vapor compression refrigeration systems. An absorption refrigeration system is designed on the basis of a detailed treatment of the thermodynamics of the lithium bromide-water combination selected as the absorbent-refrigerant pair. (Attention is also given to the aqua-ammonia combination.) Comparison with an ideal Carnot system provides an indication of the relative efficiencies of the absorption unit and a Rankine cycle-vapor compression unit, which can operate at higher temperatures than the lithium bromide absorption system. Energy storage, heat rejection, and the use of evaporative coolers or night radiation for cooling are also considered.

J.M.B.

# Environmental Action Reprint Series TH7413.C64 1977

SIZING, INSTALLATION, AND OPERATION OF  
SYSTEMS FOR THE SOLAR HEATING AND  
COOLING OF RESIDENTIAL BUILDINGS, by  
Dan Ward, Susumu Karaki, and George Lof

Textbook developed by the Solar Energy Applications Laboratory at Colorado State University to develop the capabilities of home building industry practitioners to size, install, and operate solar heating and cooling systems for residential buildings. This very extensive, detailed, and complete manual covers almost all aspects of current solar energy design and installation. Oriented toward the architect, engineer, and builder and installer of solar systems. Bibliography, worksheets. (Available at slightly lower cost from the Government Printing Office)

460 pages, paperbound (October, 1977) . \$8 75

DESIGN OF SYSTEMS FOR THE SOLAR  
HEATING AND COOLING OF RESIDENTIAL  
BUILDINGS, by Byron Winn, Susumu Karaki, and  
George Lof

Textbook developed by the Solar Energy Applications Laboratory at Colorado State University to train home designers and builders in the fundamentals of solar hydronic and air systems for space heating and cooling and domestic hot water heating for residential buildings. With *Sizing, Installation, and Operation of Systems*, it forms a complete background in the design of solar systems. Includes design calculations, heating load, collectors, storage systems, controls, and much more. (Available at slightly lower cost from the Government Printing Office)

610 pages, paperbound (October, 1977) . \$10 50

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Colorado. State University, Fort  
Collins. Solar Energy Applications  
Laboratory.

Solar heating and cooling of  
residential buildings : design of  
systems / prepared by Solar Energy  
Applications Laboratory, Colorado  
State University. — [Washington] :  
U.S. Dept. of Commerce : for sale by  
the Supt. of Docs., U.S. Govt. Print.  
Off., 1977.

647 p. in various pagings : ill. ;  
28 cm.

A78-43968 Solar cooling and heating: Architectural, engineering, and legal aspects; Proceedings of the Forum, Miami Beach, Fla., December 13-15, 1976. Volumes 1, 2, & 3. Forum supported by the Energy Research and Development Administration and University of Miami. Edited by T. N. Veziroglu (Miami, University, Coral Gables, Fla.). Washington, D.C., Hemisphere Publishing Corp., 1978. Vol. 1, 328 p.; vol. 2, 382 p.; vol. 3, 398 p. Price of three volumes, \$120. (For individual items see A78-43969 to A78-43999)

Architectural considerations and solar buildings are discussed along with flat plate collectors, concentrating tracking collectors, concentrating passive collectors, aspects of energy storage, cooling systems, heating systems, cooling and heating systems, questions of system simulation and control, and economic and legal aspects. Attention is given to the suntrap insulator/insulator, solar aesthetics and incentives, the solar energy research facility at the University of Texas at Arlington, an integrated wind/solar dwelling project, solar energy for the Hotel/Motel industry, an investigation into solar heating with some methods for convection suppression, the comparative performance of several flat plate designs, the characteristics of a subatmospheric distributed flow flat plate collector, the performance of low cost solar panels, a laboratory solar pond, heliostat structural stability as a function of solar heating and ambient temperature changes, the optimization of heat exchangers for solar concentrators, long duration earth storage of solar energy, the geothermal storage of solar energy for electric power generation, and a field study of a solar energy assisted heat pump heating system.



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International Telephone and Telegraph Corporation. Fluid Handling Division. Solar heating systems design manual. [Norton Grove, Ill.] : Fluid Handling Division, Training & Education Dept., International Telephone and Telegraph Corp., 1977.

130 p. in various pagings : ill. ;  
28 cm. \$2.50  
Cover title. 'Bulletin TESE-576,  
revision 1.'.

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European solar houses : conference at the North East London Polytechnic (C8), April 1976. -- London : International Solar Energy Society, U.K. Section, [1976]  
[4], 60 p. : ill., plans ; 30 cm.  
Cover title.  
Includes bibliographical references.  
ISBN 0-904963-11-X  
1. Solar heating--Congresses. 2. Solar houses--Europe, Western--Congresses. I. International Solar Energy Society. U.K. Section. 697'.78'094

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Chauliaquet, Charles  
L'énergie solaire dans le bâtiment / par Charles Chauliaquet assisté de Pierre Baratsabal et Jean-Pierre Batellier. -- Paris : Editions Eyrolles, c1977.  
2020 p. : ill. ; 25 cm.  
1. Solar energy. 2. Architecture and solar radiation. I. Baratsabal, Pierre. II. Batellier, Jean-Pierre. II. Title. 621.47

Although heating conversions may initially be substantial investments, "money invested in solar energy will increase the value of your house," according to Bruce Cassiday, author of The Complete Solar Book (World, Mead & Co., \$8.95)

DESIGNING AND BUILDING A SOLAR HOUSE:  
YOUR PLACE IN THE SUN. Watson, D.  
Charlotte, VT: Garden Way Publishing (1977).  
282p. \$8.95.

Solar space heating in past and present architecture is reviewed in Chapter 1. In Chapters 2 through 5, the basic methods and principles of operation of passive and active solar heating are presented. The purpose is to describe how particular types of solar equipment fit into the overall heating-system design. The operation of a solar heating system is presented as a series of three steps: solar heat collection, its storage, and its distribution to the house interior. In Chapter 6, solar heating is shown to be part of a total approach to energy conservation in building, and is termed, "ecodesign," to describe the many techniques of house-planning and construction that can be used to reduce fuel consumption. Chapter 7 compares six alternative approaches to solar house heating, each with different installation costs and heating energy results. These alternatives, ranging from a small solar installation (for domestic water heating or auxiliary solar heating only) to a large-capacity solar space heating system, are compared in terms of economic payback in four northern climates. The methods of calculation are described in an Appendix by which readers can evaluate their own choices in terms of local climate, installation cost and financing charges. The basic steps in planning a solar house project are described in Chapter 8, from site planning and design to construction, and checklists are provided of important points to consider under each of these topics. The many ways by which to proceed toward realizing a solar project are discussed. These include working with solar design consultants, equipment suppliers, and builders. (MCU)

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Chouard, Philippe  
Bilan thermique d'une maison solaire : méthode de calcul rapide / Philippe Chouard, Henri Michel, Michel F. Simon. -- Paris : Editions Eyrolles, 1977.  
164 p. : ill. -- (Collection de la direction des études et recherches d'électricité de France ISSN 0399-4198)  
Includes index.  
1. Solar houses. 2. Solar heating. I. Michel, Henri, joint author. II. Simon, Michel F. joint author. III. Title. III. Series. 697'.73

**THE SOLAR HOME BOOK.** By Bruce Anderson with Michael Rordan. 1977. Cheshire Books, Church Hill, Harrisville, NH 03450, 297 pp., paperback \$7.50.

An introduction and guide to the residential uses of solar energy, it focuses on the application of solar heating to home design and includes detailed discussions of solar cooling and water heating. Headings include solar architecture, fundamentals, direct solar heating, passive systems, indirect solar energy systems, do-it-yourself information, and an appendix including climatic and design data. Also provided are directories of architects, designers and engineers and manufacturers of solar equipment.

TH **Solar dwelling design concepts.** New  
7413 **York : Drake Publishers, 1977.**  
.S6 **144 p. : ill. ; 22 x 28 cm. pbk.**  
**: \$6.95**  
**1. Solar heating. 2. Solar houses --**  
**Design and construction.**  
**728 77-6919 0-847315-74-6 77V31587**

TH **Applications of solar energy for heating and**  
7413 **cooling of buildings / edited by Richard C.**  
.A46 **Jordan and Benjamin Y. H. Liu, prepared by**  
1977 **the American Society of Heating, Refrigerating**  
**and Air-Conditioning Engineers, Inc.**  
**under contract no. H-2352R for the Depart-**  
**ment of Housing and Urban Development, En-**  
**ergy, Building Technology and Standards**  
**Division and the Energy Research and Develop-**  
**ment Administration, Office of Solar, Geo-**  
**thermal and Advanced Energy Systems, Division**  
**of Solar Energy. -- New York : ASHRAE,**  
**1977. (Continued on card 2)**

TH **Applications of solar energy for heating and**  
7413 **cooling of buildings ... 1977. (Card 3)**  
.A46 **and Air-Conditioning Engineers. IV.**  
1977 **United States. Dept. of Housing and Urban**  
**Development. Division of Energy, Building**  
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TH **Practical guide to solar homes / by the**  
7414 **editors of Hudson home guides. -- New**  
.P7 **York : Van Nostrand Reinhold Co., 1978,**  
1978 **cl977.**  
**143 p. : ill. (some col.) : 29 cm.**  
**Bibliography: p. 140.**  
**ISBN 0-442-22594-6**  
**1. Solar houses. I. Hudson home guides.**  
**II. Solar home.**

**Royal Society of London**  
**Philosophical Transactions,**  
**Ser.A, v.295, no.1414**

**Feb. 7, 1**  
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**SOLAR ENERGY. (A discussion held Nov.15-16,1978.**  
**Organized by George Porter and William Hawthorne).**

**G. O. G. LÖF** *P.349*  
**Solar space heating with air and liquid systems**

**B. J. BRINKWORTH**  
**Results of solar heating experiments** *P.361*

**J. B. COMLY** *P.415*  
**Solar heating and air conditioning**

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International Symposium-Workshop on Solar Energy : [symposium lectures], 16-22 June 1978, Cairo, Egypt / presented by Clean Energy Research Institute, University of Miami, Florida ; sponsored by National Science Foundation ; edited by T. Nejat Veziroglu, Homer W. Miser. -- Is. 1. v. 1. 1978.

PRINCIPLES OF SOLAR COOLING AND HEATING /  
A. J. Parker, Mueller Associates, Baltimore, Maryland, U.S.A.

SOLAR HEATING AND VENTILATING BY NATURAL MEANS /  
E. Bilgen, Ecole Polytechnique, Montreal, Quebec, Canada

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Thermal storage and heat transfer in solar energy systems : presented at the winter annual meeting of the American Society of Mechanical Engineers, San Francisco, California, December 10-15, 1978 / sponsored by the Solar Energy Division, ASME, the Heat Transfer Division, ASME ; edited by Frank Kreith ... [et al.]. -- New York : ASME, c1978.  
v, 79 p. : ill. ; 28 cm.  
Includes bibliographical references.  
1. Solar heating--Congresses. 2. Heat storage. 3. Heat--Transmission. I. Kreith, Frank. II. American Society of Mechanical Engineers. Solar Energy Division. III. American Society of Mechanical Engineers. Heat Transfer Division.

TH  
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1977  
Anderson, Bruce N.  
Solar energy: fundamentals in building design / Bruce Anderson. -- New York : McGraw-Hill, c1977.  
ix, 374 p. : ill. ; 25 cm.

Containing practical, nontechnical information on virtually every aspect of the collection of solar heat, this reference book covers good building design, passive uses of solar energy, complex solar HVAC systems and solar water heating. Reflecting the author's extensive experience in building design, general contracting, product development, systems engineering, consulting and social impact and utilization research, the volume compares the relative merits of various methods of solar collection. It shows professionals how to evaluate products and detect ineffective equipment. One section discusses methods of incorporating the collection of solar heat into the actual fabric of the building itself. A major theme is energy conserving design, including weather and insulating values of materials. In addition, the book features a step-by-step process for determining the output of solar collectors and their proper size for a given building.

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SOLAR ENERGY FOR HEATING AND COOLING OF BUILDINGS. (Energy Technology Review No. 7) by Arthur R. Patton. 1975. Noyes Data Corp, Park Ridge, NJ 07656. 328 pp., bound. \$24.

The beginning chapters deal with: Components for solar heating and cooling systems; Chronology of experimental systems; Descriptions of experimental systems; Simulated systems; Feasibility studies for large scale applications. The next three chapters are taken from studies prepared by General Electric, Westinghouse and TRW. The next chapter is about the Colorado State University integrated system. The last two chapters are: Other ongoing and proposed research, and commercially available solar hardware.

TH Foster, William Murchison, 1931-  
7413 Homeowner's guide to solar heating & cool-  
.F67 ing / by William M. Foster. -- 1st ed. --  
Blue Ridge Summit, Pa. : G/L Tab Books,  
c1976.

196 p. : ill. ; 22 cm.

A practical handbook for consumer's guidance on solar heating/cooling, the text covers: system components, typical system arrangements, sizing of system and major components, and special discussions of solar water heaters and solar heating of swimming pools. Contour maps of annual heating degree days and mean solar radiation are presented for the continental U.S. (48 states), along with numerical data for the 50 states. Abundant diagrams and photographs illustrate the layout, assembly, and functioning of components, subsystems, and systems. Numerous particular solar heating installations are described as illustrative examples. R.D.V.

YOUR HOME'S SOLAR POTENTIAL. Spatzgang,  
I.; Walle, M. Barrington, NJ; Edmund  
Scientific Co. (1976). 60p.

This survey book offers a professional method of assessing your property's solar potential. Chapter I reviews the suitability of solar energy and the world energy crisis. Chapter II poses the ten most frequently asked questions about free solar energy and provides the answers. Chapter III surveys the fringe benefits about solar energy. Chapter IV lists the seven major factors concerning the evaluation of the home's solar potential, its existing heating system; its heat loss; its orientation and available sunlight; its roof slope; its exposure to sunlight; its indoor installation restrictions; and its outdoor installation restrictions. The following chapter will tell you why each of these factors is so important; how it affects your home's solar potential. Tally sheets are provided on which to score each solar potential factor. The book also includes lists of information sources, books, authors, government

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Rankins, William H.  
The solar energy notebook / written by  
William H. Rankins III and David A. Wilson;  
photography by Faris A. Ashkar. -- Black  
Mountain, N. C. : Lorien House, c1976.  
56 p.

#### UNDERSTANDING THE PROBLEM\*

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| 6  | Chapter 1 | The Availability of Solar Energy |
| 13 | Chapter 2 | Solar Collectors                 |
| 16 | Chapter 3 | Heat Storage                     |
| 19 | Chapter 4 | Heating Equipment                |
| 21 | Chapter 5 | Hot Water                        |
| 23 | Chapter 6 | A Warm House                     |

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Bereny, Justin A.  
Survey of the emerging solar energy in-  
dustry / compiled and written by Justin A.  
Bereny ; edited by Francis deWinter. --  
1977 ed. -- San Mateo, Calif. : Solar  
Energy Information Services. c1977.

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#### Optimal Insulation of Pipes and Tanks for Solar Heating Systems. Topical Report.

ALO-5319-2 PC \$5.25/MF \$3.50

A compact and time effective insulation design procedure for solar heating system piping and water-filled thermal storage tanks was developed. Recognizing the particular sensitivity of solar systems to cost, the economic aspect of the problem is treated by a comprehensive present-value life-cycle cost analysis. In the development of the method, a numerical sensitivity analysis was performed to determine the relative effects of all relevant independent variables (within their pertinent ranges) on piping and tank heat transfer coefficient values.

**THE ATYPICAL MATHEW SOLAR HOUSE AT COOS  
BAY, OREGON**

John S. Reynolds, M. Steven Baker,  
Robert L. Gray, Milton B. Larson and Henry  
Mathew

Solar Energy, vol. 19, no. 3, 1977, p. 219-  
232

**Abstract**—The Mathew solar house in Coos Bay, Oregon is an atypical solar house in several respects:  
Its location on the cloudy winter Oregon coast.  
Its combination of near-vertical collector and near-horizontal reflector.  
Its unusually large 8,000 gallon storage tank.  
Its combination of near-identical collectors; one on the house, the other freestanding.  
This paper assesses the contributions made by solar energy in space heating.

**NSO-12003/** Little (Arthur D.), Inc., Cambridge, Mass.  
**SOLAR HEATING AND COOLING OF BUILDINGS (SHACOB)**  
**COMMERCIALIZATION REPORT. PART B: ANALYSIS OF**  
**MARKET DEVELOPMENT. VOLUME 2 Final Report**  
Sep. 1977 88 p

(DOE/TIC-10071) Avail: NTIS HC A05/MF A01

The SHACOB Commercialization Model is designed to gauge the impacts of selected Federal incentive programs to encourage the development of solar energy equipment for hot water heating, space heating and space cooling in residential and commercial buildings. The model was implemented as a FORTRAN program and is presently running on the FEA computer system. It is used via the super WYLBUR data management system at FEA. Some modeling results are presented  
DOE

**A79-34017** The solar house. J. P. Michel (Ordre des Architectes, Neuilly-sur-Seine, Hauts-de-Seine, France). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 2. (A79-34002 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 871-901.

Research and development relating to solar houses in France are discussed. Emphasis is placed on solar system design, house architecture, and economic aspects of solar heating. Existing solar houses in France are briefly surveyed.  
B.J.

**54431** (DOE/TIC-10385) Solar heating and cooling of buildings (SHACOB) commercialization report: options and strategies. Part A. Volume II. Technical report. Final report. (Midwest Research Inst., Kansas City, MO (USA); Federal Energy Administration, Washington, DC (USA)). 15 Jul 1977. 181p. Dep. NTIS, PC A09/MFA01.

The national and regional perspectives for SHACOB are presented. An overview is given of the participants in SHACOB commercialization. Economic, institutional, legal, and other barriers constraining commercialization are discussed. Various analytical models are examined which project the future extent of SHACOB use or market penetration and future SHACOB to US energy supplies under alternative government policies. The results for the baseline case (no further government action, of several market penetration models are presented. Possible ways to overcome each of the barriers are presented. Qualitative analyses are given for the various incentives. Each incentive is examined to assess its impact on barriers to SHACOB commercialization and its impact on various income and interest groups. Individual incentives are compared and combined into alternative policy strategies and options. (MHR)

**54432** (DOE/TIC-10386) Solar heating and cooling of buildings (SHACOB) commercialization report: options and strategies. Part A. Volume III. Appendices. Final report. (Midwest Research Inst., Kansas City, MO (USA); Federal Energy Administration, Washington, DC (USA)). 15 Jul 1977. 168p. Dep. NTIS, PC A08/MFA01.

The following appendices are included: industry activities, solar commercialization activities at the state and local level, electric utility interface, description of the computer model, and comparison with other energy investments. (MHR)

**54433** (DOE/TIC-10648) Solar heating and cooling of buildings (SHACOB) commercialization report. Part B: analysis of market development. Volume III. Appendices. Final report. (Little (Arthur D.), Inc., Cambridge, MA (USA)). Sep 1977. 59p. Dep. NTIS, PC A04/MFA01.

The appendices include documentation of the SHACOB Commercialization Model, the underlying Model assumptions and the resulting data base, and incentives. (MHR)

**54434** (DOE/TIC-10744) Solar heating and cooling of buildings (SHACOB) commercialization report. Part B: analysis of market development. Volume I. Executive summary. Final report. (Little (Arthur D.), Inc., Cambridge, MA (USA)). Sep 1977. 25p. Dep. NTIS, PC A02/MFA01.

The following are summarized: programs objective and scope, quantitative results, discussion of financial incentives, model philosophy and description, industry infrastructure, and market research. (MHR)

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Graphic standards of solar energy / Spruille Braden III. Boston : CBI Pub. Co., c1977.

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Includes index.

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2. Solar houses -- Design and construction -- Graphic methods. I. Title.

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Szokolay, S. V.

Solar energy and building / S. V. Szokolay. -- 2d ed. -- London : Architectural Press ; New York : Halsted Press Division, Wiley, 1977, c1975.

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Includes bibliographical references and index.

ISBN 0-07-00235-2 (Wiley)

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Duffie, John A., joint author

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'A Wiley-Interscience publication.'

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1. Klein, Sanford A., joint author.
11. Duffie, John A., joint author.
- III. Title.

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**Solar Energy Seminar, University of Regina and University of Saskatchewan, 1976.**

Applications of solar energy : proceedings of the Solar Energy Seminar / editor, Peter J. Catania. Regina, Sask. : University of Regina, Canadian Plains Research Center, 1976.

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Ray E. Chant,  
Director of Industrial Research, University of Manitoba, Winnipeg, Manitoba . . . . . 48

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 HOMES. By M. Albert, Joseph M. Miller, Jr.,  
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CN-142,372 1976  
 SOLAR DWELLING DESIGN CONCEPTS. May 1976. 146p.

Department of Housing and Urban HUD-PDR-156  
 Development, Washington, D. C.  
 Office of Policy Development and Research  
 AIA Research Corp., Washington, D. C.  
 Contract IAA H-5574 TH 7413.56

Power sources, Solar - Heating & cooling  
 Buildings, Solar

MOTHER'S SOLAR HEATING SYSTEM.

The Mother Earth News, no. 36, May 1976, p.96-98.

It's been almost a year since MOTHER set out to warm  
 1,600 square feet of her editorial office space with the  
 sun ... and—as we reported on page 100 of our last issue—that  
 original goal is now a reality. Today, MOTHER's editorial  
 department is (at least in part) solar heated. And we're tanta-  
 lizingly close to using the sun to supply a full 100% of the  
 Btu's we need to warm that 1,600 square feet right through  
 the winter!

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Solar systems, simulation, design...c1976.  
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**Solar Energy Seminar, University of Regina and University of Saskatchewan, 1976.**  
**Applications of solar energy : proceedings of the Solar Energy Seminar / editor, Peter J. Catania. Regina, Sask. : University of Regina, Canadian Plains Research Center, 1976.**

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**NASA-ASEE SUMMER FACULTY FELLOWSHIP PROGRAM**  
**RESEARCH. (Prepared for NASA HQ, Office of**  
**Univ. Affairs). Aug. 1976.**

Mr. John Russell  
 Instructor  
 Calhoun College

**Research - ASEE**  
**Research - NASA**  
**Education**

Baseline Studies on the  
 Experimental Design and Test Criteria  
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International and U.S. programs, solar flux :  
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**N76-28616** / Mosley (Terrell E.), Inc., Lynchburg, Va.  
**SOLAR HEATING SYSTEM INSTALLED AT LYNCHBURG,**  
**VIRGINIA**  
 1 Dec. 1976 174 p  
 (Contract E(49-18)-2388)  
 (NASA-CR-150729) Avail: NTIS HC A06/MF A01 CSCL  
 108

A solar space and domestic hot water preheating system  
 was designed and installed in a retrofitted 1780 sq ft office  
 building. The 400 sq ft. water cooled flat plate collector is mounted  
 facing south at a 50 deg slope on the flat roof of an adjoining  
 warehouse which shelters a 2,000 gal insulated steel tank with  
 a Bitumastic interior lining. In addition to the collector and the  
 tank, the system comprises a gas auxiliary boiler, a duct  
 distribution system utilizing a hot water duct coil and water-to-  
 air heat pump, and a hot water preheater. The system is fully  
 automatic. Installation, operation, and maintenance instructions  
 are included. A.R.H.

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Solar systems, simulation, design : joint conference, American Section, International Solar Energy Society and Solar Energy Society of Canada, Inc., August 15-20, 1976. Winnipeg / editor, K. W. Boer. — Cape Canaveral, Fla. : American Section of the International Solar Energy Society, c1976.

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Proceedings of the solar energy for hot water heating one-day workshop, April 15, 1976, University of Hawaii at Manoa, Campus Center Ballroom / [conducted by University of Hawaii Center for Engineering Research, Hawaii Natural Energy Institute in cooperation with American Institute of Architects et al.].. — [Honolulu : University of Hawaii at Manoa, 1976]

vi, 74 p. : ill. ; 28 cm.  
Bibliography: p. 22.

A FORCED CIRCULATION SYSTEM FOR SOLAR WATER HEATING  
G.J. Parker  
Solar Energy, v.18, no.5, 1976, p.475-479

The work reported here gives the results of a final year student project carried out under the supervision of the author to examine the possibility of using a forced circulation system also operated by solar energy via solar (photovoltaic) cells. The cost of such a device could be offset by savings in using the existing ground level storage tank and savings in the size of the interconnecting pipework required. Such a system would also be to some extent self-controlling in that pumping would only occur at the times when the absorbers were also receiving solar radiation.

The study first examined the characteristics of solar cells, then an estimate of the power requirement for a typical installation was made. A motor-pump unit was developed which met some of the requirements and finally the unit was tested in a simple solar water heating circuit.

## **SOLAR POOL HEATERS (No. 101) \$2.00**

If you are planning to install a solar pool heater, or are just curious about them, this publication is a must. SOLAR POOL HEATERS starts with a description of how pools lose heat and ways to stop it. Then, it goes on to describe and evaluate many of the solar pool heating systems now on the market. Finally, you are shown how to design, build, and install your own do-it-yourself solar pool heater. Well illustrated, 32 Pages

**HORIZON INDUSTRIES**  
12606 Burton Street  
North Hollywood, CA 91605

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Solar systems, simulation, design : joint conference, American Section, International Solar Energy Society and Solar Energy Society of Canada, Inc., August 15-20, 1976. Winnipeg / editor, K. W. Boer. — Cape Canaveral, Fla. : American Section of the International Solar Energy Society, c1976. x, 424 p. : ill. ; 28 cm. — (Sharing the sun ; v. 4)

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Department of Housing and Urban Development, Washington, D. C. HUD-PDR-156  
Office of Policy Development and Research  
AIA Research Corp., Washington, D. C.  
Contract IAA H-5574

Power sources, Solar - Heating & cooling Buildings

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A78-18067 A solar house instrumentation and control system. R. L. Schmiesing, R. N. Miller, and M. L. Baumgartner (U.S. Air Force Academy, Colorado Springs, Colo.). In: Annual Asilomar Conference on Circuits, Systems, and Computers, 10th, Pacific Grove, Calif., November 22-24, 1976, Conference Record. (A78-18051 05-59) North Hollywood, Calif., Western Periodicals Co., 1977, p. 403-407.

This paper describes the instrumentation and control system built for the USAF Academy Solar Test House. It is built around a microcomputer and includes a 64-channel analog multiplexer, temperature, flow, and weather transducers and flow-rate controls. Data is recorded on-site on either teletype paper tape and/or a cassette recorder. Also discussed is a remote communication adaptor which allows monitoring of analog variables at a remote site via a pair of coaxial cables.  
(Author)

N77-22673/ Department of Health, Education, and Welfare,  
Washington, D.C. Office of Consumer Affairs.

# BUYING SOLAR

Joe Dawson Jun 1976 81 p refs  
(PB-262134/0; FEA/G-76/154) Avail: NTIS  
HC A05/MF A01 CSCL 13A

Guidelines for the consumer interested in buying a solar system are provided to help the homeowner considering the use of solar energy for space heating and cooling, and domestic water heating. The guidelines also help the consumer to make informed decisions based on geographic location, type of home, quality of insulation, present energy costs, and type of solar system intended for purchase. Engineering terms used to evaluate or describe solar products are also included. GRA

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Business, commercial, poster session, miscellaneous : joint conference, American Section, International Solar Energy Society and Solar Energy Society of Canada, inc., August 15-20, 1976, Winnipeg / edi-

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 Winnipeg / editor, K. W. Boer. — Cape  
 Canaveral, Fla. : American Section of the  
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## SOLAR - PHOTOVOLTAIC SYSTEMS

**N80-10676#** National Bureau of Standards, Washington, D. C. National Engineering Lab.  
**A PERSPECTIVE OF A WORKSHOP ON STABILITY OF THIN FILM SOLAR CELLS AND MATERIALS** Final Report  
 Harry A. Schafft and David E. Sawyer Jun. 1979 17 p refs  
 Sponsored in part by DOE  
 (PB-297396/4; NBSIR-89-1778) Avail: NTIS  
 HC A02/MF A01 CSCL 10B

The stability of solar cells of the following three material groupings were considered: (1) Cu<sub>2</sub>S/(CdZn)S, Cu-ternaries/CdS, InP/CdS, and amorphous Si; (2) polycrystalline, MIS, and conducting-oxide Si; and (3) polycrystalline and AMOS GaAs. Considering the relative state of immaturity of these developing cells and the goal for high reliability and stability, two general areas of work are recommended. One is to develop an improved understanding of cell operation and of component structures of these cells. The other is to develop an improved measurements base. Specific needs and recommendations are provided GRA

**A79-37845** The developing role of photovoltaic generation. P. R. Wolfe (Lucas Service Overseas, Ltd., Haddenham, Bucks., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 26-29, 21 refs.

The technology of existing and future solar photovoltaic devices is discussed with a view to the role which they will play and the applications for which they will be used. A cost-effectiveness analysis (taking into account savings offered in terms of reliability) is presented in an attempt to set limits of solar applications for various projects. B.J.

**N80-15583#** Alabama Univ., Huntsville.  
**A SURVEY OF PHOTOVOLTAIC SYSTEMS**  
 Aug. 1979 213 p Sponsored in part by DOE  
 (Contract NAS8-31293)  
 (NASA-CR-150696) Avail: NTIS HC A10/MF A01 CSCL 10A

Solar photovoltaic manufacturers and suppliers are listed. Data sheets on specific products and typical operating, installation, or maintenance instructions and procedures are appended. R.E.S.

**N80-15586#** Sandia Labs., Albuquerque, N. Mex.  
**DESIGN OF PHOTOVOLTAIC SYSTEMS FOR RESIDENTIAL APPLICATIONS IN THE UNITED STATES**  
 G. J. Jones 1979 7 p refs Presented at the Photovoltaic Solar Energy Conf., West Berlin, 23 Apr. 1979  
 (Contract DE-AC04-76DP-00789)  
 (SAND-78-2186C; CONF-790457-3) Avail: NTIS  
 HC A02/MF A01

Photovoltaic system configurations for single family residences were analyzed to determine the optimum design. Cost effectiveness and the effect of climate on the 15 regions studied were determined as factors in the analysis. The interaction of the residential photovoltaic system with the local utility is discussed and the economic viability of onsite energy storage is examined. AWH

**N79-29606#** North Carolina State Univ., Raleigh. Solid State Electronics Lab.  
**A THEORETICAL ANALYSIS OF THE CURRENT-VOLTAGE CHARACTERISTICS OF SOLAR CELLS** Final Report  
 R. C. Y. Fang and J. R. Hauser Jan. 1979 334 p refs  
 (Grant NGR-34-002-195)  
 (NASA-CR-158872) Avail: NTIS HC A15/MF A01 CSCL 10A

The following topics are discussed: (1) dark current-voltage characteristics of solar cells; (2) high efficiency silicon solar cells; (3) short circuit current density as a function of temperature and the radiation intensity; (4) Keldysh-Frenkel effects and silicon solar cells; (5) thin silicon solar cells; (6) optimum solar cell designs for concentrated sunlight; (7) nonuniform illumination effects of a solar cell; and (8) high-low junction emitter solar cells.

**A79-50028 \*** Considerations for accurately determining the maximum power output of solar cells. J. W. Lathrop and J. L. Prince (Clemson University, Clemson, S.C.). In: SOUTHEASTCON '79; Proceedings of the Region 3 Conference and Exhibit, Roanoke, Va., April 1-4, 1979. (A79-50026 22-31) New York, Institute of Electrical and Electronics Engineers, Inc., 1979, p. 29-32. Contract No. JPL-954929.

The most important single electrical parameter characterizing solar cell performance is P<sub>m</sub>, the cell's maximum power output. In order to experimentally determine P<sub>m</sub> it is necessary accurately to control both illumination and cell temperature during measurements. Two quite different measurement approaches can be used: an equilibrium method and a transient flash method. Both techniques are discussed in the paper in detail. (Author)

**N79-32700#** Lincoln Lab., Mass. Inst. of Tech., Lexington  
**FIELD TESTS OF PHOTOVOLTAIC POWER SYSTEMS**  
 M. D. Pope and R. W. Matlin 1979 10 p refs Presented at the ASME Gas Turbine Closed-Cycle Session, San Diego, 11 Mar. 1979

(Contract EY-76-C-02-4094)  
 (COO-4094-32; Conf-790305-5) Avail: NTIS  
 HC A02/MF A01

Field test experience gained at existing photovoltaic test sites is discussed. These sites include a 25 kW peak power system at Mead, Nebraska, a 12 kW peak array at MIT/Lincoln Laboratory, a 1.6 kW peak PV power system at the Chicago Museum of Science and Industry, and several small (approximately 100 watts peak) arrays located in various urban and rural sites. Data are given on failures which have occurred in the field and on the frequency of unscheduled outages. Also, information is presented concerning the environmental extremes to which the systems have been exposed. Operating experience gained from these projects is discussed in the contexts of storage, reliability, safety and cost. Finally, some projects which are currently in the design are discussed. DOE



**N80-17589//** National Technical Information Service, Springfield, Va

**SILICON SOLAR CELLS, VOLUME 3. CITATIONS FROM THE NTIS DATA BASE Progress Report, Dec. 1977 - Oct. 1979**

Brian Carrigan Nov 1979 290 p Supersedes NTIS/PS 1115, NTIS/PS-77/0956, NTIS/PS-76/0800, NTIS/PS-75/628 (PB80-800691, NTIS/PS-78/1115, NTIS/PS-77/0956, NTIS/PS-76/0800, NTIS/PS-75/628) Avail. NTIS HC \$30.00/MF \$30.00 CSCL 10B

Citations of Government sponsored research reports on silicon solar cell growth and fabrication are presented. Processes covered include chemical vapor deposition, the Czochralski method, dendritic growth, ribbon growth, epitaxial growth, and silicon sheet fabrication on substrates. Silicon compound synthesis, purification, and reduction are discussed. Casting, cutting, and shaping of silicon solar cells are included. Solar energy conversion efficiency and performance are described. Abstracts on cost and production of these cells are covered. This updated bibliography contains 209 abstracts, 75 of which are new entries to the previous edition. GRA

**N80-17590//** National Technical Information Service, Springfield, Va

**SILICON SOLAR CELLS, VOLUME 2. CITATIONS FROM THE ENGINEERING INDEX DATA BASE Progress Report, 1976 - Oct. 1978**

Brian Carrigan Nov 1979 201 p (PB80-800709) Avail. NTIS HC \$30.00/MF \$30.00 CSCL 10B

Worldwide research pertaining to solar energy conversion devices using silicon ribbons, sheets, films, crystals, and wafers is cited. The preparation, purity, crystal defects, and efficiency of these cells are covered. Solar cell development costs are discussed. The effects of radiation and weathering on performance are described. This updated bibliography contains 196 abstracts, none of which are new entries to the previous edition. GRA

**N79-32702//** Lincoln Lab., Mass. Inst. of Tech., Lexington.  
**MICROPROCESSOR-CONTROLLED AUTONOMOUS SUN-FOLLOWING MOUNT FOR SOLAR PHOTOVOLTAIC ENERGY PLANNING**

Carl H. Much, Peter L. Rossini, and David G. Stuart 1979 6 p refs Presented at the IECI 1979 Conf. on Ind. Appl. of Microprocessors, Philadelphia, 19-21 Mar. 1979 (Contract EY-76-C-02-4094)

(COO-4094-34; Conf-790353-2) Avail. NTIS HC A02/MF A01

A sun-following pyroheliometer mount and control system for support of a solar photovoltaic energy program was designed. The system features the use of a microprocessor for controlling the mount and handling complex control functions required by variations in the motion of the sun. The system is a stand-alone, unattended system with capabilities for remote diagnosis by telephone. DOE

**N80-17546\*\*//** TRW Defense and Space Systems Group, Redondo Beach, Calif

**PEP SOLAR ARRAY DEFINITION STUDY Final Technical Report**

31 Dec 1979 138 p refs (Contract NAS9-15870) (NASA-CR-160457; TRW-35515-6001-RU-00) Avail. NTIS HC A07/MF A01 CSCL 10A

The conceptual design of a large, flexible, lightweight solar array is presented focusing on a solar array overview assessment, solar array blanket definition, structural-mechanical systems definition, and launch/reentry blanket protection features. The overview assessment includes a requirements and constraints review, the thermal environment assessment on the design selection, an evaluation of blanket integration sequence, a conceptual blanket/harness design, and a hot spot analysis considering the effects of shadowing and cell failures on overall array reliability. The solar array blanket definition includes the substrate design, hinge designs and blanket/harness flexibility assessment. The structural/mechanical systems definition includes an overall loads and deflection assessment, a frequency analysis of the deployed assembly, a components weights estimate, design of the blanket housing and tensioning mechanism. The launch/reentry blanket protection task includes assessment of solar cell/cover glass cushioning concepts during ascent and reentry flight condition. M G

**N79-32891//** Arizona State Univ., Tempe  
**COMBINED PHOTOVOLTAIC/THERMAL SYSTEM STUDIES**

D. L. Evans, W. A. Facinelli, and R. T. Otterbein Aug. 1978 183 p refs

(Contract EY 76-C-04-0789) (SAND-78-7031) Avail. NTIS HC A09/MF A01

Modelling of concentrating combined collectors (those that produce both electricity from solar cells as well as thermal energy from the sun's rays) is discussed. Particular attention is devoted to accurately modelling the IV curves of present day 2 x 2 cm silicon cells designed for concentration. Also discussed is modelling of storage batteries, regulators and inverters all of which are usually found in photovoltaic systems. The models devised were formalized in subroutines that are compatible with TRNSYS. Some preliminary systems studies for both constant collector inlet fluid temperature and floating temperature systems are reported. DOE

**A80-18751**

The physics and chemistry of solar cells. K. W. Boer (Delaware University; SES, Inc., Newark, Del.). (International Conference on the Photochemical Conversion and Storage of Solar Energy, 2nd, Cambridge, England, Aug. 10-12, 1978.) Journal of Photochemistry, vol. 10, Jan. 1979, p. 77-110. 52 refs. Research supported by SES, Inc.

The physics of the photovoltaic effect is analyzed using the example of a frontwall solar cell. The effect results from the interplay of the emitter, in which minority carriers are generated via absorbed light and diffuse to the junction, and the junction, in which the essential voltage drop occurs. The interplay is established by the minority carrier density at the emitter-junction interface, acting as prominent boundary condition, and connecting current through the device with applied voltage. The chemistry of the interlayer between emitter and junction has essential influence on this boundary condition by determining interface recombination and space charge. Both of these determine band connection and performance of the device. A brief review of material properties in the light of the basic cell operation is given. (Author)

**A79-50184**

Efficiency of tandem solar cell systems as a function of temperature and solar energy concentration ratio. N. A. Gokcen (U.S. of Mines Thermodynamics Laboratory, Albany, Ore.) and J. J. Osterski (Brown University, Providence, R.I.). Solar Energy, vol. 1, Mar.-May 1979, p. 271-286. 11 refs. Contract No. EY-76-C-03-1579.

A comprehensive theoretical analysis of tandem photovoltaic solar cells as a function of temperature and solar concentration ratio is presented. The relation governing the characteristics of the solar cells was derived, and the overall efficiencies of tandem cell stacks of up to 24 cells with energy gaps in the 0.7 to 3.6 eV range were calculated for temperatures up to 500 K, and for illumination by an AMO solar spectrum of 1, 100, 500, and 1000 suns concentration ratios. The calculations show that the optimized overall efficiency for ideal diodes has a limiting value of approximately 70% for 200 K and concentration ratio of 1000. Most of the gain in efficiency occurs between six and ten semiconductors in the tandem system, so that for 300 K and 1000 concentration ratio, an optimized six cell system has a theoretical limit efficiency of about 53%. A.T.

A79-53494

On the design and operation of electrochemical solar cells. S. Kar (Indian Institute of Technology, Kanpur, India), K. Rajeshwar, P. Singh, and J. DuBow (Colorado State University, Fort Collins, Colo.). *Solar Energy*, vol. 23, no. 2, 1979, p. 129-139. 64 refs. Research supported by the Colorado Energy Research Institute.

The theoretical principals underlying the design and operation of electrochemical solar cells are reviewed. These devices are discussed in terms of a modified Metal-Insulator-Semiconductor (MIS) model in which the interfacial layer in MIS solar cells is replaced by the electrolyte. Electrostatic aspects of electrochemical solar cells are analyzed with the help of energy band diagrams and compared with those for conventional solid state solar cells. The key factors for efficient conversion of optical to electrical energy utilizing electrochemical solar cells are also highlighted from the point of view of barrier formation, carrier transport, and equivalent circuits. (Author)

# PHOTOVOLTAIC SOLAR CELL ARRAY USED FOR SUPPLEMENTAL POWER GENERATION. A. S. Barker, Jr.

*Solar Energy*, vol 23, no 5, 1979, p. 427-434.

**Abstract**—A study of the performance of a silicon cell non-tracking photovoltaic array has been made over a three year period. The array provided power in parallel with commercial utility power in a shared mode which makes use of all the solar energy generated. Tests of degradation, dirt accumulation, compatibility with telephone plant, and day by day performance were performed. A method is developed for predicting the energy output of a non-tracking array based on standard global insolation measurements.

N80-17588/ National Technical Information Service, Springfield, Va.

**SILICON SOLAR CELLS, VOLUME 3. CITATIONS FROM THE ENGINEERING INDEX DATA BASE** Progress Report. Nov. 1978 - Oct. 1979

Brian Carrigan Nov. 1979 176 p Supersedes NTIS/PS-1116. NTIS/PS-77/0958, NTIS/PS-76/0801 (PB80-600717; NTIS/PS-78/1116; NTIS/PS-77/0958; NTIS/PS-76/0801) Avail. NTIS HC \$30.00/MF \$30.00 CSCL 10B

Worldwide research on the development of solar energy conversion devices using silicon ribbons, sheets, films, crystals, and wafers is cited. The preparation, purity, crystal defects, and efficiency of these cells are covered. The economics of solar cell development is discussed. The effects of radiation and weathering on performance are included. This updated bibliography contains 171 abstracts, all of which are new entries to the previous edition. GRA

# OPTIMIZATION OF MULTI-LAYER FRONT-CONTACT GRID PATTERNS FOR SOLAR CELLS A. Flat and A. G. Milnes

*Solar Energy*, vol. 23, no. 4, 1979, pp. 289-299.

**Abstract**—In a front-contact grid pattern for a solar cell there is a trade-off necessary between shadowing loss and excessive power loss due to voltage drop in the metalization itself. If the metalization is too little there may be excessive contact resistance to the underlying semiconductor and insufficient coverage to control losses in the thin front-surface layer of the solar cell. Optimization of grid pattern area and geometry is considered analytically to minimize total losses.

Worthwhile performance advantages are shown to be possible, particularly in concentrator systems, if multi-layer grid patterns are used. The current carrying fingers should be approximately square in metal cross section and the main current feedout bars should not only be wider but also thicker than the primary collecting fingers. This is termed multi-level metalization.

Effective use of multi-level grid metalization allows much greater concentration-to-loss ratio for a cell of large area and permits good performance from cells of high front-layer sheet resistance.

54334 (SERI/TP-49-185) Photovoltaic material & device measurements workshop: focus on polycrystalline thin film cells. (Solar Energy Research Inst., Golden, CO (USA)). 1979. Contract EG-77-C-01-4042. 190p. (CONF-790601-). Dep. NTIS, PC A09/MF A01.

From Photovoltaic material and device measurement workshop; Arlington, VA, USA (11 Jun 1979).

The general purpose of the workshop was to accelerate the development of thin film solar cells by improving the versatility and reliability of material and device measurement techniques. Papers were presented under the following sessions: structural/chemical session; optical/electro-optical session; charge transport session; and poster session. Each paper was processed for EDB.

# POWER LOSS IN PHOTOVOLTAIC ARRAYS DUE TO MISMATCH IN CELL CHARACTERISTICS. L. L. Bucciarelli, Jr.

*Solar Energy*, vol 23, no 4, 1979, p. 277-288.

**Abstract**—Variations in the current-voltage characteristics of photovoltaic cells can lead to significant power loss "due to mismatch" when the cells are connected together in a network. This study explores how this mismatch loss depends on variations in max-power current and max-power voltage from cell to cell. An analysis of a series string is first performed. Losses in a parallel string are also determined. Estimates of mismatch losses in more complex arrays are then obtained. In addition to generally excellent comparison with several numerical studies, results show that, for a series string, there exists a critical magnitude of deviation in cell max-power current beyond which the power loss due to mismatch is sensitive to both the number of cells placed in series and the shape of the probability density function defining variations in max-power current. This critical level also depends on the cell fill-factor.

**A LOW-COST SOLAR-CELL FRONT CONTACT USING TRAPPED SILVER MESH AND ELECTROSTATIC BONDING**  
Geoffrey A. Landis and Peter R. Younger

IEEE Transactions on Components, Hybrids, and Manufacturing Technology, vol. CHMT-2, no.3, Sept. 1979, pp. 350-358.

**Abstract**—One of the major costs of modern solar-cell manufacture is that of applying a metallized contact grid to the cell front surface. If solar energy is to become a viable source of low-cost electricity, this expense must be reduced significantly. To keep efficiency high, a metallization grid must provide narrow closely-spaced high conductivity lines. A new system to provide this contact with a silver mesh trapped between the cell and an encapsulating glass cover has been demonstrated. Borosilicate glass is permanently joined to the cell by electrostatic bonding, an adhesive-free field-assisted glass-metal sealing technique. During this process the glass is deformed around the silver mesh to form a permanent optically coupled integral bond to the cell. This hermetic seal prevents the silver from oxidizing and destroying the electrical contact formed during the bonding process. Cells produced this way have been demonstrated with curve fill factors of 0.69. A thin titanium layer evaporated on the mesh seems to improve the results. Specific contact resistance measured for this system is on the order of 20-30 mΩ-cm<sup>2</sup>.

**NSO-18514/** Midwest Research Inst., Golden, Colo  
**PROCEEDINGS: PHOTOVOLTAICS USER REVIEW PANEL**  
S. Carroll Aug. 1979 26 p refs Proc held at Golden, Colo., 6-7 Mar. 1979  
(Contract EG-77-C-01-4042)  
(SERI/TP-69-276) Avail. NTIS HC A03/MF A01

The discussions, recommendations, and conclusions of the photovoltaics user review panel are presented. The purpose of the panel discussion was to determine the technical information dissemination (TID) needs for target audiences, to reach agreement on what informational products could fill these needs and who should produce the materials, and to establish priorities for the need for the TID products. Technological areas discussed include photovoltaics, solar thermal power, biomass, wind energy conversion, and ocean thermal energy conversion. DOE

**NASA CP-2097**

**1979**

**SOLAR CELL HIGH EFFICIENCY AND RADIATION DAMAGE - 1979.** (3rd Conf. held LeRC, June 13-14, 1979). 1979. 307p.

**Conference on Solar Cell High Efficiency and Radiation Damage**

**June 13-14, 1979**

Progress in the effort to increase the end-of-life efficiency of solar cells for space use is assessed. Silicon solar cell efficiency, radiation effects, and gallium arsenide cells are emphasized. For individual titles, see N79-32641 through N79-32673.

**TK  
2960  
.S53**

**Sittig, Marshall**  
**Solar cells for photovoltaic generation of electricity : materials, devices, and applications / Marshall Sittig.** Park Ridge, N.J. : Noyes Data Corp., 1978.  
x, 350 p. : ill. ; 25 cm. (Energy technology review ; no. 27) \$48.00  
Includes indexes. 1. Photography:

**1. Solar batteries -- Patents. 1.**

(Continued on card 2)

**N79-32718/** Brookhaven National Lab., Upton, N. Y. Medical Dept.

**AVOIDING FUTURE HEALTH PROBLEMS RELATED TO SOLAR ENERGY (PHOTOVOLTAIC) TECHNOLOGY**

Louis V. Stang 4 Apr. 1979 25 p refs Presented at the Conf. on Health Implications of the New Energy Technol., Park City, Utah, 4 Apr. 1979

(Contract EY-76-C-02-0016)

(BNL-25935; Conf-790447-1) Avail. NTIS HC A02/MF A01

The hazards involved in disposing of solar cells at the end of their service life are discussed. Several chemical elements that are likely candidates for photovoltaic development are enumerated. The present state of knowledge concerning their toxicities are commented on briefly, and studies that should be undertaken in the near future to provide adequate information on these toxicities are suggested. DOE

## Photoelectric cells

1979

SILICON COATING OF CERAMIC SUBSTRATES FOR LOW COST SOLAR CELL APPLICATIONS\*, by R.B. Maciolek, J.D. Heaps and J.D. Zook, *Journal of Electronic Materials*, vol. 8, no. 1, Jan. 1979, p.31-46.

Mullite ceramic substrates were coated with silicon using a unique method of growth designed to produce low-cost material suitable for terrestrial based solar cell applications. Pieces of mullite were carbon coated on one side and then dipped into molten silicon. The silicon wet the mullite only where the carbon was applied. Directional solidification occurs upon withdrawal. The film thicknesses were reasonably uniform over the area and could be controlled by varying the melt temperature and withdrawal rate, with higher temperatures and faster pull rates giving thinner films. Typical thicknesses of dip coated layers ranged between 20 and 150µm. The layers consist of large elongated grains aligned in the direction of withdrawal. The mullite substrates are slowly dissolved by the molten silicon resulting in some contamination of the silicon layers upon solidification.

SOLAR PHOTOVOLTAIC ENERGY. Henry Ehrenreich, and John H. Martin.

Physics today, vol 32, no. 9, September 1979  
p. 25-32.

The study conducted for the American Physical Society investigated general systems questions, solar cell technologies and directions for future research

HIGH ENERGY PROTON RADIATION DAMAGE TO (AlGa)As - GaAs Solar Cells. R. Loo, L. Goldhammer, S. Kamath and R.C. Knechtli. June 1979. 37p.

Hughes Research Labs.,  
(Hughes Aircraft Co.)  
Malibu, Calif.  
NASA NAS1-14727

REPORTS: A COMBINED IRRADIANCE-TRANSMITTANCE SOLAR SPECTRUM AND ITS APPLICATION TO PHOTOVOLTAIC EFFICIENCY CALCULATIONS.

Science, vol 204, no 4393, May 1979, p. 611-645.

*Abstract. SOLTRAN is a flexible computer model for the direct solar beam intensity spectrum at the earth's surface. It has been derived by combining the extra-terrestrial solar spectrum with the atmospheric transmittance spectrum. Application of SOLTRAN to the calculation of the potential efficiency of photovoltaic cells demonstrates the effect of atmospheric absorption bands. These bands permit unequivocal assignment of optimum energy gap values.*

A Burst of Energy in Photovoltaics. Special Report.  
by J. Javetski

Electronics, Vol. 52, No. 15, 19 July 1979, p. 105-122

Part 1: Governments Look to the Sun. Page 106.

Part 2: The Push to Production in Silicon. p. 108

Part 3: Alternatives to Silicon. p. 113

Part 4: Concentrator systems. p. 117

Part 5: Subsystems and Applications. p. 120

ND0-186867 Los Alamos Scientific Lab., N. Mex.  
DECENTRALIZED SOLAR PHOTOVOLTAIC ENERGY SYSTEMS

M. C. Krupsa Jan. 1979 110 p refs  
(Contract W-7408-eng-36)

(LA-7866-TASE) Avail: NTIS HC A06/MF A01

A model residential photovoltaic system which utilizes a solar cell array roof shingle combination is discussed in relation to developing and generating the environmental data for decentralized solar photovoltaic systems. Material requirements, operating residuals, land requirements, water requirements, production processes, and production residuals for the systems operation are examined. Environmental, health, safety, and resource availability impacts are reported. AWH

84327 (DOE/ET/23103-6) Photovoltaic effect, its present understanding and remaining mysteries. Boer, K.W. (Delaware Univ., Newark (USA); SES, Inc., Newark, DE (USA)). 1979. Contract EX-76-C-23-1030. 5p. (CONF-790541-44). Dep. NTIS, PC A02/MF A01.

From International Solar Energy Society meeting; Atlanta, GA, USA (28 May 1979).

The present phenomenological understanding of the photovoltaic effect and solar cells is discussed. Unexplained questions and problems with the effects of various device parameters on the current-voltage characteristics are discussed, and the need for more sophisticated theoretical analyses of photovoltaic cells is stressed. 26 references. (WHK)

TK	<b>Intersociety Energy Conversion Engineering</b>	
2896	Conference, 14th, Boston, 1979.	
.I55	Proceedings of the 14th Intersociety	
1979	Energy Conversion Engineering Conference,	
	Boston, Massachusetts, August 5-10, 1979.	
	-- Washington, D. C. : American Chemical	
	Society, c1979.	
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	<b>Application of a GaAs Photovoltaic Solar</b>	
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	<b>Johnson, G.C. Chang and R.L. McCarthy</b> .....	<b>303</b>

**N79-33844\*** Spire Corp., Bedford, Mass.  
**INTEGRAL GLASS ENCAPSULATION FOR SOLAR ARRAYS**  
**Quarterly Progress Report**  
 Jun. 1979 18 p. Sponsored by NASA and DOE Prepared for  
 JPL

(Contract JPL-954521)  
 (NASA-CR-182381; DOE/JPL-954521-79/2, QPR-10) Avail:

NTIS HC A02/MF A01 CSCL 10A  
 Progress in the development of permanent, integral glass  
 encapsulation of terrestrial solar photovoltaic arrays by electrostat-  
 ic bonding is reported. Two basic types of electrostatically bonded  
 modules were demonstrated and their reliability proven in  
 accelerated environmental testing. Economic analyses indicate  
 that electrostatic bonding can be a cost effective, practical, and  
 automatable process for large-scale production of arrays with  
 lifetimes of more than 20 years. J.M.S.

**N79-32844\*** National Aeronautics and Space Administration,  
 Langley Research Center, Hampton, Va.

**LANGLEY PROGRAM OF GaAs SOLAR CELLS**

E. J. Conway In NASA, Lewis Res. Center Solar Cell High  
 Efficiency and Radiation Damage, 1979 Aug. 1979 p 13-14  
 (For primary document see N79-32840 23-44)

Avail: NTIS HC A13/MF A01 CSCL 10A  
 A brief overview of the development of GaAs solar cell  
 technology is provided. An 18 to 20 percent AMO efficiency,  
 stability under radiation and elevated-temperature operation, and  
 high power-to-weight ratio are among the factors studied. Cell  
 cost and availability are also examined. J.M.S.

**64296** (CONF-781191-) Proceedings of the US DOE Photovol-  
 taics Technology Development and Applications Program Review.  
 (OAO Corp., Beltsville, MD (USA)). 1978. Contract NAS-7-100-  
 689604. 543p. Dep. NTIS, PC A23/MF A01.

From DOE photovoltaics technology development and appli-  
 cations program review conference; Arlington, VA, USA (7 Nov  
 1978).

The proceedings include summaries of thirty-eight presenta-  
 tions under the following sections: overview and project status  
 reports; standards performance criteria; cost/economics; concentra-  
 tor and flat panel technology alternative for 50 cents/watt; balance  
 of system technology; and experience gained from the design and  
 operation of photovoltaic systems.

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1978

IEEE Photovoltaic Specialists Conference,  
13th, Washington, D.C., 1978.  
The conference record of the thirteenth  
IEEE Photovoltaic Specialists Conference  
— 1978 : June 5-8, 1978, Washington, D.C.  
— New York : Institute of Electrical and  
Electronics Engineers, c1978.  
1346 p. : ill. ; 29 cm.  
"78CH1319-3"  
Includes bibliographical references  
and index.  
1. Solar batteries—Congresses.  
x. Institute of Electrical and Elec-  
tronics Engineers. 621.475

A79-32238 Efficient solar cell with an intermediate wave-  
length conversion for operation with concentrators. Zh. I. Alferov,  
V. M. Andreev, D. Z. Garbuzov, B. V. Egorov, V. R. Larionov, V. D.  
Rumiantsev, and O. M. Fedorova (Akademiia Nauk SSSR, Fiziko-  
Tekhnicheskii Institut, Leningrad, USSR). (*Pisma v Zhurnal Tekh-  
nicheskoi Fiziki*, vol. 4, Sept. 28, 1978, p. 1128-1130.) *Soviet  
Technical Physics Letters*, vol. 4, Sept. 1978, p. 455. Translation.

The paper reports results of a study of the I-V characteristics of  
solar cells with intermediate wavelength conversion which have a  
sensitive area of 10 mm diameter and a photolithographic contact  
grid. The samples were grown by liquid-phase epitaxy on substrates  
of epitaxial films of tin-doped n-GaAs. It is found that cells of this  
type can be used successfully in solar power systems with extremely  
high concentration of sunlight and effective heat removal. B.J.

A78-51819 Solar energy conversion through phase trans-  
formations. R. C. Srivastava (Birla Institute of Technology and  
Science, Pilani, India), A. S. N. Murthy, and G. R. Saini (Indian  
Institute of Technology, New Delhi, India). *International Journal of  
Energy Research*, vol. 2, Jan.-Mar. 1978, p. 43-45, 12 refs.

Sodium thiosulphate pentahydrate and sodium sulphate deca-  
hydrate show appreciable potential differences and currents when  
the solid phase is in contact with its molten phase. The studies offer  
a new method for converting solar energy into electrical power.  
(Author)

TJ  
153  
.E4797  
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Energy Technology Conference, 5th, Washington,  
D.C., 1978.  
Energy technology V : challenges to  
technology : proceedings of the fifth  
Energy Technology Conference, February 27-  
March 1, 1978, Washington, D.C. / edited by  
Richard F. Hill. -- Washington : Government  
Institutes, 1978.  
xiii, 1063 p. : ill.  
1. Power (Mechanics)—Congresses.

#### STATUS OF PHOTOVOLTAIC SYSTEMS AND APPLICATIONS

D. G. Schueler, Supervisor, Photovoltaic Projects, Sandia Laboratories

Solar photovoltaic conversion systems, based on the direct  
conversion of solar energy to electricity through the use of solar  
cells, have the potential of providing a significant source of clean  
and renewable energy in a variety of applications. The Department of  
Energy's Photovoltaic Conversion Program is a multifaceted approach  
emphasizing the development of low-cost and reliable photovoltaic  
systems and the fielding of applications experiments to produce data  
on the performance and reliability of such systems. This paper will  
discuss results of system conceptual design and analysis studies for  
residential and central generation stations. A number of currently  
operating and planned application experiments ranging in size from a  
few hundred watts to 0.5 megawatts will also be reviewed.

#### TERRESTRIAL SOLAR CELLS - PRESENT AND FUTURE, by

B. T. Debney and J. R. Knight

Contemporary Physics, vol. 19, no. 1, January 1978,

p. 25-45 In this paper the principles of operation of various types of solar cell are  
described. Progress in photovoltaics is traced through the development of the  
monocrystalline silicon cell for space applications where the emphasis is upon reliability  
and power weight ratio, to terrestrial cells where the emphasis is upon low cost  
production. The role of other contenders such as polycrystalline silicon, amorphous  
silicon and cuprous sulphide/cadmium sulphide is discussed. Both silicon and  
gallium arsenide cells may be operated in conjunction with optical concentrators and  
sun tracking equipment. This approach is compared with the usual flat array  
approach. The various national programmes for developing photovoltaic power  
sources are described, and the cost and production goals laid down in the American  
programme are quoted. Photovoltaic power sources are capital intensive, but once  
installed are cheap to operate and maintain, and in this respect they differ from  
conventional power sources. The economic viability of photovoltaic power sources  
depends critically upon the magnitude of real interest rates, and we show that when  
inflation is taken into account, photovoltaic power sources are competitive in many  
situations.

MIS SOLAR CELLS: A REVIEW, by David L. Pulfrey  
IEEE Transactions on Electron Devices, vol. ED-25  
no. 11, November 1978, p. 1308-1317

**Abstract:** The metal-thin-film insulator-semiconductor (MIS) structure is currently receiving much attention in solar-cell studies. Both theoretical and practical investigations indicate that this structure offers a means of overcoming the principal deficiency of Schottky barrier solar cells, namely low open-circuit photovoltage, while maintaining the attractive features that have led the metal-semiconductor junction to be considered as a possible alternative to the p-n junction for large-area, terrestrial, solar-cell applications.

The thin insulating layer allows control over not only the magnitude of the dark current flowing through the diode, but also the dominant type (majority or minority carrier) of this current. Desirably low values of dark current have been postulated for majority carrier devices incorporating suitable charge-trapping centres, located either within the insulator or at the semiconductor-insulator interface, and for minority carrier devices employing suitable insulator thicknesses, metal work functions, and semiconductor resistivities.

Theories based on these models are reviewed in this paper and their relevance to explaining photovoltage enhancement in practical Si and GaAs MIS cells is examined. The factors affecting other salient solar-cell properties (photocurrent, fill factor, conversion efficiency) are also considered and suggestions as to the parameters limiting present device performance are given.

TL AAS Annual Meeting, 24th, Washington, D.C.,  
787 1978.  
.A2 Space shuttle and spacelab utilization  
v.37 ...c1978  
pt.1 At head of title: An American Astronautical  
Society publication.  
Includes bibliographical references.  
ISBN 0-87703-096-0  
1. Reusable space vehicles--Congresses.  
2. Orbiting astronomical laboratories--  
Congresses. I. Morgenthaler, George W.  
III. Polateln, Manfred. III. Goldard

Advantages of Thin Silicon Solar Cells for Use in Space  
(AAS 78-024a)  
Owen S. Denman  
p.331

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1978

Southeastern Region 3 Conference, Atlanta,  
Ga., 1978.

A creative exchange of ideas : proceedings of Southeastern '78 Region 3 Conference, Atlanta, Ga., April 10, 11, 12, 1978, Sheraton - Atlanta. -- New York : Institute of Electrical and Electronics Engineers, c1978.

1. AC Model of Silicon Solar Cells and Predictions 253  
L. A. Mallette and R. L. Phillips  
Florida Technological University  
Electrical Engineering and Communications Sciences  
Orlando, FL

Solar cells have traditionally been used for direct sunlight to energy conversion, but there has been relatively little investigation into their use as a low data rate optical detector. A model of a solar cell, and typical numerical values for the elements, are presented. The response to a pulse of light is given, for variations in background illumination, using typical values.

QC  
171  
.B3  
v.10

Physics of thin films : advances in research and development, v.10 / edited by Georg Hass, Maurice H. Francombe. -- New York : Academic Press, 1978.  
xi, 324 p. : ill.

Spectrally Selective Surfaces for Photothermal Solar Energy Conversion

R. E. Hahn and B. O. Seraphin

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II. Fundamentals of Photothermal Solar Energy Conversion .....	4
III. Physical Processes and Materials Systems for Spectrally Selective Surfaces .....	28
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Royal Society of London  
Philosophical Transactions,  
Ser.A, v.295, no.1414

Feb.7,  
1980

SOLAR ENERGY. (A discussion held Nov.15-16,1978.  
Organized by George Porter and William Hawthorne).

H. DURAND

Present status and future prospects of silicon solar cell arrays and systems

S. WAGNER

Heterojunction solar cells

Discussion: H. TABOR, P. T. LANDSBERG, F. A. HOLLAND

TK  
2960  
•P84

Pulfrey, David L.

Photovoltaic power generation /  
David L. Pulfrey. New York : Van  
Nostrand Reinhold Co., 1978.

xiv, 218 p. : ill. ; 24 cm.

Includes bibliographical references  
and index.

#### ECONOMIC ASSESSMENT OF PHOTOVOLTAIC POWER SYSTEMS 171

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| 6.2 The Cost of Electricity from Photovoltaic Power Systems | 175 |
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| 6.2.2 Intermediate level systems                            | 186 |
| 6.2.3 Central power station systems                         | 188 |

A79-40881 Photovoltaic Specialists Conference, 13th,  
Washington, D.C., June 5-8, 1978. Conference Record. Conference  
sponsored by the Institute of Electrical and Electronics Engineers.  
New York, Institute of Electrical and Electronics Engineers, Inc.,  
1978. 1388 p. Members, \$60.; nonmembers, \$80. (For individual  
items see A79-40882 to A79-41101)

These papers deal with recent developments in the design,  
manufacture, and terrestrial as well as space application of photovol-  
taic devices. Topics include the future of photovoltaics, tests and  
demonstrations of photovoltaic power systems, measurements of  
photovoltaic material properties, radiation and space environmental  
effects on solar cells, materials and process development for low-cost  
production of photovoltaic cells, solar cells from 'newer' materials,  
and space solar-array technology. Other papers consider low-cost  
R&D for large-scale production, solar cells from alternative materials,  
silicon material and sheet growth, Cu(x)S/CdS cells, silicon cells for  
space applications, polycrystalline material and impurity effects in  
silicon, and In-Sn oxide cells. Space radiation effects on GaAs cells  
are also discussed, along with device and module technology for  
low-cost production, silicon MIS cells, solar-concentrator system  
elements, endurance field tests, tandem cells, and terrestrial applica-  
tions of photovoltaic power systems. F.G.M.

A79-31924 \* / Photovoltaics and solar thermal conversion to  
electricity - Status and prospects. M. E. Alper (California Institute of  
Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Energy  
and aerospace; Proceedings of the Anglo/American Conference,  
London, England, December 5-7, 1978. (A79-31908 12-44) London,  
Royal Aeronautical Society, 1979. 16 p. 16 refs.

Photovoltaic power system technology development includes  
flat-plate silicon solar arrays and concentrating solar cell systems,  
which use silicon and other cell materials such as gallium arsenide.  
System designs and applications include small remote power systems  
ranging in size from tens of watts to tens of kilowatts, intermediate  
load-center applications ranging in size from tens to hundreds of  
kilowatts, and large central plant installations, as well as grid-  
connected rooftop applications. The thermal conversion program is  
concerned with large central power systems and small power  
applications. G.R.

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T Simulation Symposium, 11th, Tampa, Fla.,  
57.62 1979.

.S57 Eleventh Annual Simulation Symposium /  
107A edited by Philip N. Adams, Eugene W.

CONTRIBUTION TO SOLVING THE ENERGY CRISIS: SIMULATING THE PROSPECTS FOR LOW  
COST ENERGY THROUGH SILICON CELLS, Mr. Alexander Kran, IBM. 8/5-20.....

Abstract. PECAN (Photovoltaic Energy Conversion Analysis) is a highly  
interactive decision analysis and support system. It simulates the prospects  
for widespread use of solar cells for the generation of electrical power.

PECAN consists of a set of integrated APL functions for evaluating the potential  
of terrestrial photovoltaics. Specifically, the system is a deterministic  
simulator, which translates present and future manufacturing technology into  
economic and financial terms, using the production unit concept. It guides  
solar cell development in three areas: tactical decision making, strategic  
planning, and the formulation of alternative options.

PHOTOVOLTAICS REVIEW, A WAY TO UTILIZE THE ELEC-  
TRIFYING RAYS OF THE SUN, by Michael C. Merchant.  
Sunworld, vol. 2, no. 1, February 1978, p. 2-10.

#### THIN FILMS - PRESENT AND FUTURE (Special issue)

Thin film solar cells. .... P. 99  
T. J. Coultts (Cranfield, Gt. Britain) -118

SOLAR CELL MATERIALS AND THEIR BASIC PARAMETERS,  
E. Bucher  
Applied Physics, vol. 17, no. 1, September 1978,  
p. 1-26

Abstract. Parameters such as the energy gap  $E_g$ , open circuit voltage  $V_{oc}$ , short circuit  
current density  $j_{sc}$ , fill factor F.F., efficiency  $\eta$ , antireflection coating condition A.R. and  
illumination conditions of currently known photovoltaic diodes are reviewed and tabu-  
lated, followed by some critical comments.

A78-30743 The sun on a semiconductor. M. Laliberte  
(Electric Power Research Institute, Palo Alto, Calif.). EPRI Journal,  
vol. 3, Mar. 1978, p. 20-25.

Advantages of photovoltaic electric systems are related to the  
absence of intermediate conversion stages involving thermal and/or  
mechanical energy, potentially very long component lifetimes, low  
maintenance costs, the utilization of diffuse solar radiation, and the  
modular system characteristics. The main obstacle to a widespread  
use of photovoltaic systems is currently the high cost of device  
manufacture. In the case of silicon cells, the cost of a peak kilowatt  
of electric generating capacity is about \$15,000. This figure has to be  
compared with today's conventional power plant cost of \$200-\$1000  
per kilowatt of rated generating capacity. DOE wants to achieve a  
cost of \$500 per peak kilowatt for single-crystal silicon cells  
encapsulated in panels for 1986. Alternative approaches for lowering  
costs are related to the concept of thin-film solar cells utilizing  
cadmium sulfide, indium phosphide, or amorphous silicon, deposited  
on an inexpensive substrate. G.H.

THE INFLUENCE OF TUNNELING EFFECTS ON THE  
EFFICIENCY OF HETEROJUNCTION SOLAR CELLS.  
P. De Visschere & H. J. Pauwels  
Applied Physics, Vol. 15, No. 4, April 1978,  
p. 413-422

Abstract. A theoretical model is developed which presents the transport properties through  
the space charge region of a  $p^+n$  heterojunction solar cell, whereby not only recombination  
through interface states but also tunneling through potential barriers is taken into account. It  
is investigated whether tunneling can give rise to optimum heterojunction structures which  
have better efficiencies than without tunneling. It is found that only if the strongly doped  
semiconductor has an optimum bandgap and the weakly doped semiconductor a larger  
bandgap, tunneling can make the structure optimum. In all other cases of optimum  
structures, tunneling deteriorates the efficiency.

RECENT PROGRESS IN THIN-FILM SOLAR CELLS.  
J. I. B. Wilson, J. McGill and D. Weaire  
Advances in Physics, vol. 27, no. 3, May 1978, p. 365-  
385

The depletion of energy resources should produce an increase in the range of  
applications for terrestrial solar cells. The main factor determining the extent of  
this increase will be cost. In this respect, thin-film solar cells are particularly  
promising. Recent work on cells based on doped amorphous silicon is reviewed  
in detail. The properties of this relatively new material are still poorly under-  
stood.

**AUTOMATIC TEST EQUIPMENT.** (Special issue: (Contains papers in five categories: (1) Automatic Test System Architecture; (2) Automatic Test Equipment Designs; (3) Automated Measurement Subsystems; (4) Automatic Testing Techniques; (5) Automatic Control System Instrumentation).

Microprocessor-Based Solar Cell Measurement System

L. Costafra, A. Alabau, M. Sanchez-Monell, J. Cabedony, and J. Ventosa

**Abstract**—A microprocessor-based solar cell standard characteristics measurement system is described. Data acquisition and digital conversion of the current-to-voltage characteristics and the spectral response allows the performance of several operations as averaging, storage, minicomputer connection, and parameter determination of the theoretical models introduced.

Several results are shown concerning the accuracy of the method on the determination of series resistance, reverse saturation current, and the minority carriers lifetime on the base region of solar cells.

**IONIZED DOPANT CONCENTRATIONS AT THE HEAVILY DOPED SURFACE OF A SILICON SOLAR CELL.** Irving Weinberg, Jacob D. Broder, George A. Marzaris, Jr., and Len Rau, LERC. Dec. 1978. 18p.

NASA TP-1347

**Astronautics and Aeronautics, v. 16, no. 11**  
p. 32-33

**HIGH EFFICIENCY LOW COST SOLAR CELL POWER.** Ivan Bekay, and Wade Blocker. (A new concept for solar power modules could dramatically increase cell efficiency to lower the cost of spacecraft power, boost electric propulsion, and cut your electric bills).

**SOLAR**

**HIGH-EFFICIENCY ORGANIC CELLS**

D. L. Morel, A. K. Ghosh, T. Feng, E. L. Storgryn,  
P. E. Purwin, R. F. Shaw and C. Fishman  
Appl. Phys. Lett., vol. 32, no. 8, April 15, 1978  
p. 495-497

Organic solar cells based on merocyanine dyes have exhibited sunlight efficiencies in excess of 1% at  $\sim 100 \text{ mW/cm}^2$ . This represents a significant improvement over previously reported values and brings such devices into the realm of practicality. The devices exhibit  $V_{oc}$ 's as high as 1.2 V but are presently limited by field-dependent energy-dependent quantum efficiency. Though monochromatic efficiencies approaching 100% occur at high photon energies, these diminish to  $\sim 35\%$  at the main absorption peak in the visible. Based upon sunlight absorption, theoretical efficiencies for these devices appear high.

**THEORY AND APPLICATIONS FOR OPTIMIZATION OF EVERY PART OF A PHOTOVOLTAIC SYSTEM,** by David Redfield  
Solar Energy, vol. 21, no. 2, 1978, p. 107-112

**Abstract**—A general method is presented for quantitatively optimizing the design of every part and fabrication step of an entire photovoltaic system, based on the criterion of minimum cost/Watt for the system output power. It is shown that no element or process step can be optimized properly by considering only its own cost and performance. Moreover, a fractional performance loss at any fabrication step within the cell or array produces the same fractional increase in the cost/Watt of the entire array, but not of the full system. One general equation is found to be capable of optimizing all parts of a system, although the cell and array steps are basically different from the power-handling elements. Applications of this analysis are given to show (a) when should Si wafers be cut to increase their packing fraction; and (b) what are the optimum dimensions for solar cell metallizations. The optimum shadow fraction of the fine grid is shown to be independent of metal cost and resistivity as well as cell size. The optimum thicknesses of both the fine grid and the bus bar are substantially greater than the values in general use, and the total array cost has a major effect on these values. By analogy, this analysis is adaptable to other solar energy systems.

**DEGRADATION OF SOLAR CELL EFFICIENCY BY SHEET RESISTANCE,** by K. Lehofer and A. Fedotowsky  
Solar Energy, vol. 21, no. 2, 1978, p. 81-86

**Abstract**—The efficiency degradation of solar cells due to sheet resistance-generated losses is computed as a function of light intensity and electrode spacing. The degradation derived by Heizer and Chu is shown to be 33 per cent too large at small electrode spacing. We give an approximate analytic relation for the efficiency degradation and derive from it the electrode spacing which minimizes the combined losses due to sheet resistance and electrode shading. An electrode configuration which prevents extreme power loss by local short circuits in the photojunction is described.

TA 418.9 National SAMPE Symposium and Exhibition, 23rd, Anaheim, Calif., 1978.

.C6 Selective application of materials for products and energy / Society for the Advancement of Material and Process Engineering. -- Azusa, Calif. : Society for the Advancement of Material and Process Engineering, 1978.

A3  
1978

RECENT DEVELOPMENTS IN LOW COST SILICON SOLAR CELLS FOR  
TERRESTRIAL APPLICATIONS 354

Martin H. Leipold

The state of development of low cost production of silicon sheet material for use in terrestrial photovoltaic energy systems is reviewed. Emphasis is placed on the materials requirements both from a technological and economic point of view. In several areas, the successful development of cost-effective sheet is limited by the availability of useful and perhaps more important low cost materials.

PERSPECTIVES ON UTILITY CENTRAL STATION PHOTOVOLTAIC APPLICATIONS, by E. A. DeMeo and P. B. Bos

Solar Energy, vol. 21, no. 3, 1978, p. 177-192

Abstract—This report develops nominal cost and performance goals for solar photovoltaic conversion devices intended for large-scale electric utility applications. The objective is to provide an improved basis for establishing research and development priorities for photovoltaic devices and conversion concepts. Comparisons are made among a number of generic power plant conceptual designs, with the aid of an array design parameter that is defined to include array-area-related costs, overall power plant efficiency, and average available insolation. The analysis indicates that flat plate approaches without concentration or tracking have good prospects for commercial viability if device conversion efficiencies near 10 per cent can be combined with installed device costs under \$20/m<sup>2</sup> (\$2/ft<sup>2</sup>) and device lifetimes in excess of 20 years. Thin-film approaches have potential for achieving these cost and performance goals because of low material content and potentially low fabrication costs. Very high efficiency devices coupled with concentrations in excess of about 100:1 represent a viable alternative if sufficiently high conversion efficiencies (25% or more) can be achieved. Such devices are likely to be expensive, but high concentration may make their costs acceptable. Several device types and converter approaches exist or have been proposed that have potential for reaching these efficiencies. In contrast to flat plate approaches, however, high concentration approaches may have the disadvantage of requiring active cooling. Approaches employing low-to-medium concentration appear to have limited potential for large-scale applications. Required efficiencies are likely to be comparable to those needed for high-concentration approaches, but the concentration ratios are not likely to be high enough to make the photovoltaic device costs tolerable.

"WET-TYPE" SOLAR CELLS WITH SEMICONDUCTOR ELECTRODES, by H. Tsubomura, M. Matsumura, K. Nakatani, K. Yamamoto and K. Maeda  
Solar Energy, vol. 21, no. 2, p. 93-98

Abstract—The photovoltages and photocurrents arising from "wet" solar cells of the type, (semiconductor electrode/aqueous solution of electrolyte/platinum electrode), have been measured and discussed. Earlier work by the present authors and others on such "wet" solar cells using a semiconductor electrode is briefly and critically reviewed. The effect of dyes, either dissolved in the solution or coated on the electrode surface, was studied in detail including the effect of reducing agents, which turned out to act as electron suppliers. The photovoltaic effects in nonaqueous solutions were also studied. The photocurrent efficiencies of the dye-sensitized cells were improved by increasing the quantities of dyes adsorbed on the surface and reached 19 per cent for monochromatic illumination at the wavelengths of the absorption peaks of the dyes and under sufficient anodic biases.

HASA CP-2058 Photoelectric cells

FUTURE ORBITAL POWER SYSTEMS TECHNOLOGY REQUIREMENTS.  
(Symposium held LeRC, May 31-June 1, 1978). Sept. 1978.  
322p.

Symposium on Future Orbital Power May 31-June 1,  
Systems Technology Requirements 1978

A BRIEF SURVEY OF THE SOLAR CELL STATE-OF-THE-ART  
Daniel T. Bernatowicz, NASA Lewis Research Center p. 133  
SOLAR CELL WORKSHOP . . . p. 275 . . . . .

PERFORMANCE OF A TILTED SOLAR CELL UNDER VARIOUS  
ATMOSPHERIC CONDITIONS, by J. V. Deye.  
Solar Energy, vol. 21, no. 4, 1978, p. 263-271.

A feasibility study of open cycle air conditioning systems that use solid desiccants and solar energy has been performed. The two configurations evaluated are the ventilation mode, in which ambient air is continually introduced into the room, and the recirculation mode, in which room air is recirculated. Seasonal simulations for Miami, Florida, show that the auxiliary energy requirement for the ventilation mode is about one half that for the recirculation mode. The seasonal COP for the system using solar energy as the auxiliary is approximately 0.75. A conventional flat plate solar energy system of moderate size can provide a large fraction of the energy required to meet the sensible and latent loads of a typical house. (Author)

ORIGINAL PAGE IS  
OF POOR QUALITY

SOLAR ELECTRICITY SPEEDS DOWN TO EARTH, by  
Stanford R. Ovshinsky  
New Scientist, vol. 80, no. 1131, November 1978,  
p. 674-677

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Present silicon solar cells are far too expensive for large scale power generation. But recent exciting  
advances in the development of amorphous devices bring forward several years the day when  
installation costs could drop below those of nuclear power

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### PHOTOVOLTAIC POWER SYSTEMS: A TOUR THROUGH THE ALTERNATIVES

Henry Kelly  
Science  
Vol. 199 no. 4329 February 1978  
p. 634-643

A family of new technologies, rich in ideas, may  
provide the basis for many useful energy systems.

HIGH EFFICIENCY LOW COST SOLAR CELL POWER, by Ivan  
Bekey and Wade Blocker.  
Astronautics & Aeronautics, vol. 16, no. 11,  
November 1978, p. 32-38.

*A new concept for solar power modules could  
dramatically increase cell efficiency to lower  
the cost of spacecraft power, boost electric  
propulsion, and cut your electric bills.*

SOLAR CELLS: PLUGGING INTO THE SUN, by John C.C. Fan.  
Technology Review, vol. 80, no. 8, Aug./Sept. 1978,  
p. 14-36.

Solar cells convert sunlight into electricity silently and  
without pollution. New materials and new fabrication  
techniques may bring down their costs significantly.

### ADVANCED SILICON SOLAR CELL PRODUCTION TECHNOLOGY.

John A. Scott - Monck  
Journal of Energy, Vol. 2, No. 3, May/June  
1978, p. 131-135.

In this paper the methodology employed by Spectrolab,  
Inc. to produce more efficient silicon solar cells in a cost-  
effective manner will be described in some detail. Information  
on the types of cells now available for space flight ap-  
plications, as well as data on their electrical performance, will  
be included. In addition, projections of the types of cells that  
may achieve production status within the next two to five  
years will be offered, along with estimates of their electrical  
performance.

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Photovoltaic Solar Energy Conference, Luxem-  
bourg, Luxembourg, 1977.

Proceedings of the international con-  
ference held at Luxembourg, September 27-  
30, 1977 / Photovoltaic Solar Energy Con-  
ference. -- Dordrecht, Holland ; Boston :  
D. Reidel Pub. Co., c1977.

1373 p. : ill. : 24 cm.

At head of title: Commission of the  
European Communities.

Includes  
ences and

bibliographical refer-  
index.



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2960  
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Pulfrey, David L.  
Photovoltaic power generation /  
David L. Pulfrey. New York : Van  
Nostrand Reinhold Co., 1978.  
xiv, 218 p. : ill. ; 24 cm.  
Includes bibliographical references  
and index.

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## SOLAR CELLS FOR CONCENTRATED SUNLIGHT SYSTEMS 154

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Palz, Wolfgang  
Solar electricity : an economic  
approach to solar energy / Wolfgang  
Palz. London ; Boston : Butterworths,  
1978.  
xv, 292 p. : ill. ; 26 cm.  
Includes index. Bibliography: p.  
1. Solar power plants. 2. Solar  
energy. I. Title.  
621.475 77-3524 0-408709-10-3  
77V20639

The description of photovoltaic conversion is con-  
cerned with different kinds of solar cells  
and various kinds of photovoltaic generators.

## NOVEL MATERIALS AND DEVICES FOR SUNLIGHT CONCENTRATING SYSTEMS

H. J. Hovel

IBM J. Res. Development

Vol. 22 no. 2 March 1978

p. 112-121

In the first part of this paper, the economic advantages of high efficiency solar cells for sunlight concentration systems are illustrated. In the second part, the theoretical *limit conversion efficiencies* of single-junction solar cells are calculated as a function of temperature and intensity. In the last part, the individual novel devices and their particular advantages and disadvantages are described.

N78-26554\*// National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

### DESCRIPTION AND STATUS OF NASA-LERC/DOE PHOTOVOLTAIC APPLICATIONS SYSTEMS

Anthony F. Ratajczak 1978 10 p refs Presented at the 13th Photovoltaic Specialists Conf., Washington, D. C., 5-8 Jun. 1978; sponsored by IEEE

(Contract E(49-26)-1022)

(NASA-TM-78936; E-9679; DOE/NASA/1022-78/38) Avail:

NTIS HC A02/MF A01 CSCL 10A

Designed, fabricated and installed were 16 geographically

## PROSPECTS FOR THE USE OF AMORPHOUS SEMICONDUCTORS IN SOLAR ENERGY CONVERSION.

J. I. B. Wilson & D. Weaire

Nature, Vol. 275, No. 5676, September 14, 1978, p. 93-96.

In this article, we review some potential applications of amorphous Si in the field of solar energy conversion. These are not confined to the junction devices mentioned above, that is, solar cells, but these certainly constitute the most promising prospect.

QC3.P47

RR

## MATERIALS FOR LOW-COST SOLAR CELLS.

F.A. Shirland & P. Rai-Choudhury.

Reports on Progress in Physics, v.41, no.12, Dec.1978, p.1839-1879.

Photovoltaic materials are reviewed with regard to their possible use in systems that could provide very large amounts of electric power from the Sun before the end of the century. The key is taken to be the cost of the solar cells which are considered to be presently about two orders of magnitude too high. Only silicon, in single crystal or ribbon form, or CdS in thin-film form are thought to be sufficiently developed to permit their possible large-scale exploitation by the last decade of the century.

Silicon is considered to have the advantage over CdS at present for large-scale use because of the higher performance levels and the broader existing technology base. CdS thin films are considered to have greater potential if selected improvements can be effected in design and performance, because of lower projected cost and the ease of automating manufacture.

## PROPERTIES OF POLYCRYSTALLINE AlAs/GaAs ON GRAPHITE HETEROJUNCTIONS FOR SOLAR CELL APPLICATIONS

W.D. Johnston, Jr. and W.M. Callahan

J. Electrochem. Soc., v125, no.6, June 1978, pp977-983

Polycrystalline heterojunction material of N-AlAs/p-GaAs and P-AlAs/n-GaAs was grown in a chloride arsine vapor-phase reactor on graphite substrates. P<sup>+</sup>-AlAs/p-n GaAs structures were produced as well by postgrowth Zn diffusion. Control of nucleation and ohmic contact of the GaAs layer to the graphite was achieved with Zn doping during growth, or Ge or Sn coating of the substrate prior to growth, for p- or n-type GaAs, respectively. The N-AlAs/p-GaAs material appears promising for possible solar cell applications, but we have not succeeded in overcoming the high spreading resistance due to grain boundary scattering in the AlAs layer.

PHOTOCURRENT SPECTROSCOPY OF SEMICONDUCTOR  
ELECTRODES IN LIQUID JUNCTION SOLAR CELLS  
A. Heller, K.-C. Chang, and B. Miller  
Journal of the American Chemical Society  
Vol. 100, no. 3, February 1, 1978,  
p. 684-688.

The analysis of efficiency losses in photovoltaic solar cells requires the identification of carrier recombination centers and other mechanisms leading to photocurrent decrease.<sup>1</sup> Photocurrent spectra for semiconductor-liquid junction cells<sup>2</sup> have been used to determine band gaps and redox solution absorbance<sup>2,3</sup> but also contain many other features which relate directly to cell operation such as short- and long-wavelength defects and dependence on incident light intensity. This latter dependence may account for cell efficiency deterioration observed by others at light levels corresponding to only 0.01-0.1 of typical solar irradiance.<sup>3,4</sup>

THE PROSPECTS FOR PHOTOVOLTAIC CONVERSION.  
W.D. Johnston, Jr.  
Amer. Scientist, v.65, no.6, Nov./Dec.1977, p.729-36.

*Solar cells convert sunlight directly to electricity.  
Can they be made efficient and cheap enough to  
contribute significantly to a solar energy economy?*

A78-53487 Materials and energy; Selected topics. Edited by J. H. Wernick (Bell Telephone Laboratories, Inc., Murray Hill, N.J.). Amsterdam, North Holland Publishing Co. *Journal of Crystal Growth*, vol. 39, 1977. 217 p. \$39.25. (For individual items see A78-53488 to A78-53503)

Topics relevant to the application of photovoltaic materials, novel electrode materials, and solid electrolytes for use in solar cells are discussed. Techniques for reducing the cost of silicon solar cells are examined with attention to improved procedures for crystal growth and solar cell fabrication. Information derived from single-crystal studies is reported, and the prospects of using materials other than silicon for solar cells are explored. Transition-metal chalcogenides and electrode materials are described. M.L.

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.155

International Solar Energy Society. UK Section.  
Economic & commercial assessment of  
solar energy conversion : conference (C12)  
at the Royal Institution July 1977. —  
London : UK - ISES, c1977.  
98 p. : ill. ; 30 cm.  
Includes bibliographical references.  
1. Solar energy—Congresses.  
I. Title.

Cost Factors in Photovoltaic Energy Conversion with  
Solar Concentration  
J.E. PARROTT P.49

MAXIMISATION OF OPERATING EFFICIENCY OF SOLAR CELLS  
D. M. Divan and M. M. Hasan  
Energy Conversion, vol. 17, no. 4, 1977, p. 183-188

Abstract—Two optimal control systems have been devised for maximising the operating efficiency of a solar cell working into any load for arbitrary conditions of illumination. Considering the variation of solar intensity on an average day, the proposed techniques result in an efficiency, which is at least 17% greater than the solar cell's average operating efficiency without control.

P<sup>+</sup>/N HIGH-EFFICIENCY SILICON SOLAR CELLS.  
H.S. Bae and R.V. D'Aiello.  
Appl. Phys. Letters, v.31, no.4, Aug.1977, p.285-87.

A novel boron-diffusion process is described for the fabrication of high-efficiency P<sup>+</sup>/N silicon solar cell. Over the range of diffusion parameters investigated this diffusion process results in a boron-rich surface layer and shallow junctions (0.15-0.4 μm) having two properties important to the formation of high-efficiency solar cells—relatively low values of sheet resistance (35-140 Ω/□) which facilitates the front-surface grid-metal design and large resultant lifetimes approaching 60 μs. The characteristics of P<sup>+</sup>/N solar cells, fabricated using this diffusion process in single-crystal (CZ) silicon wafers, having AM1 efficiencies ranging from 14 to 17% are presented.



# DETERMINATION OF SOLAR CELL EQUATION PARAMETERS FROM EMPIRICAL DATA.

A. Braunstein, J. Bany and J. Appelbaum

Energy Conversion

Vol. 17 No. 1

1977

p. 1-6

**Abstract**—The determination of the solar cell equation parameters ( $I$ - $V$  characteristic) from experimental data was achieved by the least square method, where all data points were considered. The five parameters of the cell equation were transformed to a three parameter equation, resulting in a simplified solution. In the fitting procedure of the calculated  $I$ - $V$  characteristic to the experimentally measured points, the errors of the instrumentation were taken into account. The shunt resistance appeared to be important for a desired fitting accuracy.

## LABORATORY EXPERIMENTS WITH SILICON SOLAR CELLS.

D. W. Kammer and M. A. Ludington

American Journal of Physics, vol. 45, no. 7, July 1977, p. 602 - 605

The uses of silicon solar cells as subjects of experiments in undergraduate teaching laboratories are discussed. The basic theory of these cells is presented, including equivalent circuits and characteristic equations. Fundamental experiments on the power output and efficiency, which are appropriate for nonscience majors' courses, are detailed, as well as more advanced experiments on cell parameters. Experimental results and agreement with theory are presented for a typical inexpensive cell.

## SOLAR-CELL TECHNOLOGY ADVANCES - BUT SLOWLY

Dick Hackmeister

Electronic Design 26

Vol. 25 no. 26 December 20, 1977

p. 24-28

**L**ittle by little, solar-cell technology is being directed by the federal government toward increasing the nation's energy supplies. While solar-electric, or photovoltaic power systems have a long way to go before they actually compete with fossil-fueled power plants, there are signs indicating that progress is being made:

## SILICON SOLAR CELLS ON ZONE-MELTED SILICON/GRAPHITE SUBSTRATES.

T.L. Chu, et al.

J. Appl. Phys., v.48, no.8, Aug.1977, p.3576-3579.

Polycrystalline-silicon solar cells deposited on graphite substrates by conventional chemical vapor deposition techniques have low conversion efficiencies due to the carrier recombinations at grain boundaries. To reduce the concentration of grain boundaries, silicon layers deposited on graphite substrates have been zone melted to increase substantially the size of silicon crystallites. Using these silicon layers as substrates, solar cells have been deposited in a one-step process by the thermal reduction of trichlorosilane containing appropriate dopants, and AM1 efficiencies of higher than 5% have been obtained for cells of about 6-cm<sup>2</sup> area.

## RADIATION EFFECTS ON HIGH EFFICIENCY SILICON SOLAR CELLS

W. Luft

Energy Conversion, vol. 16, no. 4, 1977, p. 159 - 167

**Abstract** The performance of 10 cell types from 3 manufacturers shows non-irradiated, glass-covered cell efficiencies ranging from 10.3 to 13.6% after prolonged photon illumination for cells having thicknesses from 215 to 370  $\mu$ m.

Efficiencies after irradiation by 1-MeV electrons to a fluence of  $10^{15}$  e/cm<sup>2</sup> ranged from 8.0 to 9.2%. The degradation in power output as a result of  $10^{15}$  e/cm<sup>2</sup> irradiation ranged from 31 to 33% for cells with a 2 ohm-cm base resistivity and from 28 to 30% for 10 ohm-cm cells. Cells having a  $P^+$  back surface field showed the highest degradation in each resistivity group.

Only a cell group using float-zone material showed significant photon degradation after electron irradiation. All other cell types showed annealing of electron irradiation damage of up to 5% after  $3 \times 10^{15}$  e/cm<sup>2</sup> irradiation.

## LABORATORY EXPERIMENTS WITH SILICON SOLAR CELLS

D. W. Kammer and M. A. Ludington

American Journal of Physics, vol. 45, no. 7, July 1977, p. 602 - 605

The uses of silicon solar cells as subjects of experiments in undergraduate teaching laboratories are discussed. The basic theory of these cells is presented, including equivalent circuits and characteristic equations. Fundamental experiments on the power output and efficiency, which are appropriate for nonscience majors' courses, are detailed, as well as more advanced experiments on cell parameters. Experimental results and agreement with theory are presented for a typical inexpensive cell.



# EFFECTS OF IMPURITY REDISTRIBUTION ON THE SHORT - CIRCUIT CURRENT OF N+ -P SILICON SOLAR CELLS

E. Y. Wang and L. Hsu and H. W. Brandhorst, Jr.

Journal of the Electrochemical Society

Vol. 124 no. 12 December 1977

p. 1915-1918

The effect of impurity redistribution on the n<sup>+</sup>-diffused layer of silicon solar cells has been studied. The impurity concentration was profiled by four point-probe differential Hall and resistivity measurements. The electric field gradient and the mobility gradient in the diffused region were obtained from the impurity profiles. Short-circuit current was calculated from the effective recombination lifetime deduced from electric field gradient and mobility gradient results. The calculated short-circuit current was compared with measured values as a function of wavelengths and found to be in reasonably good agreement.

## SOLAR CELLS FOR TERRESTRIAL APPLICATION

Harold J. Hovel.

Solar Energy

Vol. 19 no. 6

1977

p.605-615.

Abstract—A review is given of solar cells for terrestrial applications. Four major categories of cells are discussed: silicon, cadmium sulfide, devices for sunlight concentration, and thin film cells. A brief description of solar photovoltaic systems is also included.

## A SI/CDS HETEROJUNCTION SOLAR CELLS.

F.M. Livingstone, et al.

J. Phys. D: Applied Phys., v.10, 1977, p.1959-1963.

Abstract. Heterojunction solar cells of the type Si-CdS have been fabricated which have efficiencies of 7% under AM1 conditions. The cells have been fabricated by depositing epitaxial CdS films on thermally cleaned silicon substrates under uv.

The efficiency of these cells has been studied over a wide range of Si resistivities and it has been found that the highest efficiency is obtained with near-intrinsic silicon. The series resistance associated with these cells results in a fill factor of 0.6.

## METEOROLOGICAL EFFECTS ON SOLAR CELLS.

J.R. Mallinson and P.T. Landsberg.

Proc. R. Soc. London. A, v.355, 1977, p.115-30.

The effect of different meteorological conditions on solar cell outputs has been investigated, using a model for a solar cell (p-on-n or n-on-p) which incorporates surface recombination, surface region electric field and series resistance. Two ways of defining 'clear' and 'cloudy' conditions have been used, and by interpolating between them we have constructed two continuous ranges of meteorological conditions. The optimum achievement of a hypothetical range of substances  $X(E_g)$  which have an energy gap  $E_g$ , but otherwise all have silicon material parameters, have been determined for each of the meteorological conditions mentioned above. The optimum material,  $X$ , for U.K. conditions is found to be  $X(1.78\text{eV})$  rather than silicon which is  $X(1.12\text{eV})$ . However, its translation into a real material or its low-cost production are not considered here.

NASA CP-2010

1977

TERRESTRIAL PHOTOVOLTAIC MEASUREMENTS - II. (Workshop sponsored by ERDA, organized by LERC and held Baton Rouge, La., Nov.10-12,1975). 1977. 404p.

Energy Research and Development

Administration, (Washington, D.C.)

Workshop on Terrestrial Photovoltaic Measurements

ERDA/NASA-

1022/76/10

Nov.10-12,

1976

Session titles

Terrestrial solar irradiance: its measurement and its effect,

Solar simulation and reference cell calibration.  
Cell and array measurement procedures.

## A FOKKER-PLANCK ANALYSIS OF PHOTOVOLTAIC SYSTEMS

Lawrence H. Goldstein

Energy

Vol. 3, no. 1, February 1978,

p. 51-62.

Abstract—The battery state-of-charge,  $S(t)$ , of an arbitrary photovoltaic system is analyzed as a Markov process driven by random white Gaussian perturbations of periodic insolation and load-demand profiles. A Fokker-Planck equation for the probability density function of  $S(t)$  is derived, and  $S(t)$  minus its mean is recognized as a nonhomogeneous Wiener-Levy process. The Fokker-Planck equation is solved under conditions of no barriers, one absorbing barrier, and two absorbing barriers, and the resulting probability density functions are used to obtain bounds on the complementary cumulative distribution function for the first passage time,  $x(t) = P\{T > t\}$ , to the completely discharged or totally charged state. Limiting expressions for these bounds as  $t \rightarrow 0$  and  $t \rightarrow \infty$  are obtained, and their asymptotic values are compared. Finally, a simple system is analyzed to provide insight into the meaning of the equations developed.

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Optical polarimetry—instrumentation and applications [seminar], August 23-24, 1977, San Diego, California / R. M. A. Azzam, David L. Coffeen, editors ; presented by the Society of Photo-optical Instrumentation Engineers in conjunction with the

Optimum Antireflection Coating for Antireflection-coated Metal-Oxide-Semiconductor (AMOS) Solar Cells  
Y. C. M. Yeh, F. P. Ernest, R. J. Stirn, Jet Propulsion Laboratory

In this paper, comprehensive methods for obtaining parameters of an optimum single-layer AR coating on an AMOS solar cell to match the entire sunlight spectrum, rather than a single wavelength, will be given. In this method, therefore, the effects of a solar spectrum, spectral response of the solar cell and optical properties of the solar cell are collectively considered.

- NASA CP-2020  
Solar Cell High Efficiency and Radiation Damage.  
A Conference held at Lewis Res. Center. April  
28-29, 1977.

#### Status of NASA-Lewis Research Center

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James A. Hutchby, NASA Langley Research Center . . . . .

GaAs Solar Cell Development

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N77-30277\*# National Aeronautics and Space Administration,  
Lewis Research Center, Cleveland, Ohio.  
RECENT DEVELOPMENTS IN PHOTOVOLTAIC ENERGY BY  
ERDA/NASA-LERC  
James N. Deyo In its Proc. of the ASPE/MSFC Symp on Eng.  
and Productivity Gains from Space Technol. May 1977 p 69-85  
(For primary document see N77-30273 21-31)  
Avail: NTIS HC A13/MF A01 CSCL 10A

PERFORMANCE ANALYSIS OF A SOLAR-ELECTRICAL  
SYSTEM WITH A LOAD AND STORAGE BATTERIES.

J. Appelbaum, A. Braunstein, and J. Bani

Energy Conversion, 1977, vol. 16, no. 3,  
p. 105-110

PHOTOVOLTAICS: THE SEMICONDUCTOR REVOLUTION  
COMES TO SOLAR

Allen L. Hammond

Science, July 29, 1977, vol. 197, no. 4302,  
p. 445 - 447

Journal of Vacuum Science & Technology Sept./Oct.  
v.14, no.5, p.1053-1216.  
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PROCEEDINGS OF THE SYMPOSIUM ON DIELECTRIC THIN  
FILMS ON SEMICONDUCTOR DEVICES. G.L. Schanable  
and J.L. Vossen, eds. (Held May 4, 1977 at RCA  
Labs., Princeton, New Jersey. Sponsored by the  
American Vacuum Society)

American Vacuum Society  
Symposium on Dielectric Thin Film  
on Semiconductor Devices

May 4,  
1977

THEORY OF THE SCHOTTKY BARRIER SOLAR CELL.  
P. T. Landsberg and C. Klumpke

Proceedings of the Royal Society of London,  
Vol. 354, no. 1676, 21 April 1977, p. 101-118

NASA CR-2800

ANALYSIS OF GaAs AND Si SOLAR ENERGY HYBRID  
SYSTEMS.

March 1977

John H. Heinbockel and A. S. Roberts, Jr.  
OLD DOMINION UNIVERSITY RESEARCH FOUNDATION  
Norfolk, Va.

30 references

for Langley Research Center

Various silicon hybrid systems are modeled and compared with a Gallium Arsenide hybrid system. The hybrid systems modeled produce electric power and also thermal power which can be used for heating or air conditioning. Various performance indices are defined and used to compare the system performance: capital cost per electric power out; capital cost per total power out; capital cost per electric power plus mechanical power; annual cost per annual electric energy; and annual cost per annual electric energy plus annual mechanical work. These performance indices indicate that concentrator hybrid systems can be cost effective when compared with present day energy costs. Realistic cost and efficiencies of GaAs and Si are respectively \$35,000/m<sup>2</sup> for 15% efficient solar cells and \$1000/m<sup>2</sup> for 10% efficient solar cells. Limiting values for annual costs are 10.3 ¢/kwh and 6.8 ¢/kwh for Si and GaAs respectively. Results demonstrate that for a given flow rate there is an optimal operating condition for maximum photovoltaic output associated with concentrator systems. Also concentrator hybrid systems produce a distinct cost advantage over flat plate hybrid systems.

N79-32737# Joint Center for Graduate Study, Richland, Wash.  
INVESTIGATION OF LOW COST SOLAR CELLS BASED ON  
Cu<sub>2</sub>O Annual Progress Report, 1 Oct. 1975 - 30 Sep.  
1976

Larry C. Olsen 30 Sep. 1976 91 p refs  
(Grant NSF AER-75-20501)  
(PB-295888/2. NSF/RANN/AER-75-20501/PR/76/3.  
NSF/RA-761743) Avail: NTIS HC A05/MF A01 CSCL 10B

Fabrication of thin-film backwall Cu/Cu<sub>2</sub>O cells, collection efficiency measurements and analysis, MIS solar cell theory, and initiation of frontwall solar cell studies are discussed. A system was established for controlled oxidation of copper. Both thick film and thin film backwall cells were fabricated and characterized. These cells typically have J about 0.00003 A/sq cm and n 3.5. Analysis of thick film diodes suggest that a high interface state density exists at the Cu-Cu<sub>2</sub>O junction. The thin film cells have very low shunt resistances due to the granular structure. Spectral collection efficiency of thin film backwall cells was measured to be 25 percent at 800 nm. Assuming a reasonable collection efficiency for backwall cells, the upper limit of performance for backwall cells is projected to be 4 percent. GRA

ACTA ELECTRONICA 20(2) 1977

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Silicon for solar cells [fr]. J J Brissot.  
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Structures for photocells: homojunctions,  
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Single crystal silicon photocells for  
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General considerations concerning simple  
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Relative cost-performance of various solar  
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The near-term prospectives for photovoltaic  
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## Power sources, Solar

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- Optics applied to solar energy conversion [seminar], August 23-24, 1977, San Diego, California / Roland Winston, A. I. Mlavsky, editors ; presented by the Society of Photo-optical Instrumentation Engineers in conjunction with the IEEE Computer Society International Optical Computing Conference 77. — Bellingham, Wash. : SPIE, c1977. viii, 95 p. : ill. ; 28 cm. — (Proceedings of the Society of Photo-optical Instrumentation Engineers ; v. 114)

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NASA CP-2020

**SOLAR CELL HIGH EFFICIENCY AND RADIATION DAMAGE.**  
(Conf. held at Lewis Research Center, Apr. 28-29, 1977). 1977. 253p.

**Conference on Solar Cell High Efficiency and Radiation Damage** Apr. 28-29, 1977

A conference on Solar Cell High Efficiency and Radiation Damage was held at the Lewis Research Center on April 28-29, 1977, in which representatives of government, industry, and universities participated. Sessions were held on silicon solar cell analysis and fundamental measurements, silicon cell technology, gallium arsenide research and technology, and radiation effects on silicon and gallium arsenide cells. This proceedings is composed of brief papers or summaries covering the formal presentations. Included also is the Chairman's summary of the meeting, which contains the major topics raised in the numerous discussion periods.

**OUTDOOR WEATHERING PERFORMANCE OF SOLAR ELECTRIC GENERATORS.** C.R. Maag, Jr.  
J. ENERGY, v.1, no.6, Nov/Dec.1977, p.376-381.

During the fall of 1974, nine companies (worldwide) offered off-the-shelf terrestrial solar electric generators. Units with peak power output near 1.5 watts were purchased from three manufacturers (or their distributors) whose product lines offered a cross section of the available market. All of the solar power supplies consisted of a panel comprised of silicon solar cells connected in a variety of series-parallel or series arrangements with a blocking diode to prevent reverse current flow when the panel was not illuminated. A description of the solar cell modules is given in Table I. In this investigation, samples of the array encapsulants plus potential encapsulation or cover materials were subjected to real-time testing for the same period as the solar arrays.

The testing period was from December 1974 to December 1975 in the mid-Atlantic region of the United States. By measuring any changes in electrical output or spectral transmission as a function of exposure time the durability and weather resistance of the modules and components could be readily assessed.



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OF POOR QUALITY

Solar energy ; chemical conversion and storage / edited by Richard R. Hautala, R. Bruce King, and Charles Kutal. -- Clifton, N.J. : Humana Press, c1979.

x, 419 p. : ill. ; 24 cm. -- (Contemporary issues in science and society)

Based on an American Chemical Society symposium held in Savannah, Georgia, in November, 1978.

Includes bibliographical references and index.

1. Solar energy -- Addresses, essays, lectures. 2. Chemical processes -- Addresses, essays, lectures. 3. Energy storage -- Addresses, essays, lectures. I. Hautala, Richard R. II. King, R. Bruce. III. Kutal, Charles. IV. American Chemical Society.

AN ELECTROCHEMICAL HEAT ENGINE FOR DIRECT SOLAR ENERGY CONVERSION. R. H. Hammond and W. M. Risen, Jr.

Solar Energy, vol 23, no 5, 1979, p. 443-449.

**Abstract** — A system is described and tested which converts heat directly into electrical energy. It employs a solution electrochemical reaction with a small polarizability and a large molar entropy change  $\Delta S$ . This is run in opposite directions in two cells: one at high temperature, where heat is absorbed, and one at low temperature, where heat is emitted. The difference in heat absorbed and heat emitted is available as electrical work; recirculation of the solutions between these cells gives a closed regenerative EMF system.

The conversion efficiency of the system is high, varying from 50 to 75 per cent of the Carnot efficiency as the power output varies from maximum to 75 per cent of maximum. The power output depends strongly upon the reaction used. For the reaction tested here, the power output density was  $6.4 \text{ W/m}^2$  of cell area for operation between  $90^\circ$  and  $30^\circ \text{C}$ . Design factors for improving power output density and minimizing costs are discussed, and basic requirements for successful cell reactions are given. The feasibility of obtaining power output on the order of  $2 \times 10^3 \text{ W/m}^2$  of cell area at 35 per cent conversion efficiency using  $300^\circ \text{C}$  input heat is discussed.

PHOTOELECTROLYSIS OF WATER WITH SEMICONDUCTORS, by M. Tomkiewicz and H. Fay.

Applied Physics, vol. 18, no. 1, January 1979, p. 1628.

The possibility of using solar radiation for the photolysis of water has aroused the imagination of scientists from many different fields. Because of the intermittent nature of solar power, practical processes for utilizing solar energy will require methods for energy conversion and for storage of the converted energy. Photoelectrolysis could provide an ecologically sound means for both: conversion of the solar energy to chemical energy in the photoelectrolytic process, and storage of this energy as gaseous or liquid oxygen and hydrogen or in compounds such as metal hydrides. Hydrogen can be used as a fuel and the piping of hydrogen may be the preferred way to transport energy in the future. An efficient photoelectrolysis process would be an ideal source of this hydrogen. Finally, photoelectrolysis represents half of the technology required to duplicate natural photosynthetic processes. The other half is the photolytic assimilation of  $\text{CO}_2$  for the synthesis of organic materials.

A80-29051

Solar energy: Chemical conversion and storage.

Edited by R. R. Hautala, R. B. King, and C. Kutal (Georgia, University, Athens, Ga.). Clifton, N.J., Humana Press, Inc., 1979. 432 p. \$34. (For individual items see A80-29052 to A80-29061)

Papers are presented on solar energy conversion in photosynthesis, the chlorophyll A water-splitting light reaction, light-induced electron-transfer reactions in solution, effect of the micellar phase on photo-induced reactions, and on reversible excited-state electron-transfer reactions of transition metal complexes. Individual topics include solar cell technology, and photocyclization. C.F.W.

R. Memming: Energy production by photoelectrochemical processes,

Philips tech. Rev. 38, 160-177, 1978/79 (No. 6).

A survey is presented of the research on photoelectrochemical solar cells, which convert solar energy into electrical or chemical energy. These cells consist of a semiconductor electrode, an electrolyte and a metal counter-electrode. The nature of power generation by light excitation is similar to that in *P-N* junctions: electron-hole pairs are created by the illumination and separated by the electric field across the space-charge layer below the semiconductor surface. The minority carriers moving towards the surface take part in an electrochemical process. A regenerative cell suitable for power generation can be made if a redox system is added to the electrolyte. Its function and construction are described in terms of the energy levels. Problems arise because of side reactions such as the anodic dissolution. The stability problem and the selection of suitable semiconductor material are discussed in detail. In addition, photoelectrolysis cells that can be applied for the production of hydrogen are described. Stable semiconductor electrodes suitable for this kind of energy conversion have large band gaps, which limits the conversion efficiencies to rather low values.

SYNTHETIC CHLOROPLASTS\*, by Melvin Calvin.

Energy Research, vol. 3, no. 1, Jan/Mar. 1979, p.73-89

The principal function of the chloroplast is to capture solar quanta and to store them in some stable form. We are in the process of trying to construct a totally synthetic system that would simulate some of the reactions of the two photosystems which occur in natural chloroplasts. These synthetic chloroplasts will not resemble the natural entity in detailed construction, as they will contain no protein.

TECHNICAL NOTE, by O.M. Williams and P.O. Carden, Solar Energy, vol. 22, no. 2, p.191-195.

SCREENING REVERSIBLE REACTIONS FOR THERMOCHEMICAL ENERGY TRANSFER.

Wentworth and Chen[1] have introduced a convenient parameter, the turning temperature  $T^*$ , for assessing the suitability of reversible chemical reactions proposed for use in solar thermochemical energy transfer systems.  $T^*$  is defined as the temperature at which neither reactant nor product formation is thermodynamically favoured and can be estimated to a good approximation from standard thermodynamic data alone.

The Wentworth and Chen definition applies only to systems operated at 1 atm pressure and is therefore unsuitable for assessing high pressure reactions such as the ammonia dissociation/synthesis

Solar energy use through biology--past, present and future. D. O. Hall.

Solar Energy. v. 22, no. 4, 1979, p. 307 - 328.

Abstract—Each year plant photosynthesis fixes about  $2 \times 10^{11}$  tonnes of carbon with an energy content of  $3 \times 10^{21}$  J—this is about  $10 \times$  the world's annual energy use and  $200 \times$  our food-energy consumption. All the atmospheric  $\text{CO}_2$  is cycled through plants every 300 yr, all the  $\text{O}_2$  every 2000 yr and all the  $\text{H}_2\text{O}$  every 2 million yr. The magnitude and role of photosynthesis is largely unrecognized principally because we utilize such a small fraction of the fixed carbon and because we do not realize the important recycling phenomena. Fortunately for us plants are very adaptable and exist in great diversity—they could thus continue indefinitely to supply us with renewable quantities of food, fibre, fuel and chemicals. Photosynthesis in the past provided all our fossil carbon resources. It now seems time that we recognize seriously and evaluate what photosynthesis can do for us in the future via traditional and non-conventional mechanisms, e.g.  $\text{H}_2$  production, carbon fixation.

A79-37850

The prospects of a biological-photochemical approach for the utilization of solar energy. D. O. Hall (King's College, London, England) and J. Coombs (Tate and Lyle Research Laboratories, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 48-53, 5 refs.

A brief review is presented of the possibilities of developing energy conversion systems based on photosynthesis and photochemistry. Tables are presented giving cost and energy yield information for dry and wet biomass and attention is given to photochemical and photobiological processes for fuel-hydrogen and electricity.

B.J.



A79-31146 # Biological conversion of solar energy (Biologicheskoe preobrazovanie solnechnoi energii). A. A. Krasnovskii. *Akademiia Nauk SSSR, Vestnik*, no. 1, 1979, p. 83-96. 17 refs. In Russian.

Some topics on biological conversion of solar energy are touched upon, including the molecular mechanism of photosynthesis, the photochemistry of chlorophyll, the mechanism of photosynthesis of hydrogen by water organism cells, and the transfer of electrons in reactions centers of photosynthesizing bacteria. It is pointed out that the limiting efficiency of photosynthesis processes is 15%, while silicon solar batteries in spacecraft can use up to 20% of the solar radiation. P.T.H.

#### THE PHOTOGALVANIC EFFECT IN A MODIFIED IRON THIONINE SYSTEM

H.Ti Tien and James M. Mountz

*J. Electrochem. Soc.*, v.125, no.6, June 1978, pp.885-886

In the course of our attempt in developing a new type of photoelectrochemical cell (8), the operation of which would be based on the combined principles of the two photoelectric effects, we have observed the photogalvanic effect in a modified thionine iron solution which should be of interest in the development of a practical photogalvanic device.

#### THE PHOTOGALVANOVOLTAIC CELL, by J. M. Mountz, and H. Ti Tien.

*Solar Energy*, vol. 21, no. 4, 1978, p. 291-295.

A method of combining a photovoltaic (PV) cell and a photogalvanic (PG) cell to obtain a photogalvanovoltic cell (PGV), which will have the combined properties and advantages of both of its constituents, is described. The PV cell immediately converts light to electricity. Although the PG cell can in principle be used either for immediate conversion or for energy storage, the specific light-induced high-energy redox species of the described PG system degenerate via the rapid back reaction which precludes use of the combined cell system as an efficient short-term storage system. Composition and properties of the PV, PG, and PGV cells are reported. Both electrodes are photoactive and the total emf produced is the sum of the single electrode potentials. The PGV process is cyclic, and it is suggested that the cell can be used to convert solar energy to electricity. M.L.

#### S/SE SUBSTITUTION IN POLYCRYSTALLINE CdSe PHOTOELECTRODES, PHOTOELECTROCHEMICAL ENERGY CONVERSION, by David Cahen

*Journal of the Electrochemical Society*, vol. 25, no. 10 October 1978, p. 1623-1628

On the basis of x-ray photoelectron spectroscopy (XPS) studies of polycrystalline CdSe electrodes, the occurrence of S/Se substitution in these electrodes, when immersed in polysulfide solution, is verified. The substitution process is enhanced considerably when the electrode is illuminated as part of a photoelectrochemical cell. The mechanism of the S/Se exchange is discussed, as well as the consequences of such an exchange for electrode stability. The resulting presence of a thin (several tens of angstroms) layer of CdS on top of the CdSe is taken into account in constructing a rough band scheme for the system. The CdS layer is shown to influence the photovoltage and, to a lesser extent, the photocurrent obtainable from this kind of photoelectrochemical cell. Its relation to the slow deactivation of highly crystalline CdSe photoelectrodes is discussed.

#### THERMOPHOTOELECTROCHEMICAL CELLS FOR SOLAR ENERGY CONVERSION.

P.V. Kamat, M.D. Karkhanavala and P.N. Moorthy  
*Solar Ener.*, v.20, no.2, 1978, p.171-173.

Photoelectrochemical cells are currently of great importance because of their potential applicability in converting light into electrical energy. Among cells of this kind, those employing dye-redox systems[1] and semiconductor-redox systems[2] have been the subject of many investigations in recent years because of their response in the visible and near UV regions making them attractive as solar energy converters. As the above photo systems do not respond in the IR region of the solar spectrum, we have investigated the feasibility of utilizing the heating effect of the latter to provide a temperature differential between the illuminated and dark half cells to determine if the efficiency of the above photoelectrochemical cells could be improved. Such cells employing both a photo- and thermal response have been designated as thermophotogalvanic cells[3].† In this paper are presented the results of experiments performed using a tungsten-halogen lamp as the light source and constant temperature water circulation to keep the half cells at the desired temperature.

# PHOTOELECTROCHEMICAL CELL WITH CADMIUM TELLURIDE FILM.

W.J. Danaher and L.E. Lyons.

Nature, v.271, Jan.12,1978, p.139.

ELLIS *et al.*<sup>1</sup> reported studies of single crystal CdX based photoelectrochemical cells when X = S, Se or Te and found that the best efficiencies were obtained when CdTe was used as the photoelectrode. Photoelectrochemical cells using thin films of CdS and CdSe have been reported by Miller and Heller<sup>2</sup> and by Hodes *et al.*<sup>3</sup> In this paper, we report on a photoelectrochemical cell using a thin polycrystalline film of CdTe.

A78-37174 Photo-galvano-voltaic cell - A new approach to the use of solar energy. H. T. Tien and J. M. Mountz (Michigan State University, East Lansing, Mich.). *International Journal of Energy Research*, vol. 2, Apr.-June 1978, p. 197-200. 9 refs. Research supported by Michigan State University.

A novel photo-electrochemical cell based on a combined principle of photogalvanic and photovoltaic effects is proposed and tested. The principal element of the cell consists of a pigmented membrane separating two aqueous solutions, one of which contains thionine dye and ferrous ions. The photo-emf generated across the cell is equal to the sum of the voltages derived from the photogalvanic and photovoltaic processes. The feasibility of such a photo-galvano-voltaic device for light transduction has been demonstrated. (Author)

TA Annual review of materials science. v. 8 /  
401 Robert A. Huggins, editor ; Richard H.  
.A7 Bube, Richard W. Roberts, associate editors.  
v.8 — Palo Alto, Calif. : Annual Reviews, Inc.,  
1978.  
524 p. : ill.  
Includes bibliographical references and  
index.  
1. Materials—Yearbooks. I. Huggins,  
Robert A. II. Bube, Richard H. III. Roberts,  
Richard W. 620.1105

# HOLE REACTIONS FROM D - ENERGY BANDS OF LAYER TYPE GROUP VI TRANSITION METAL DICHALCOGENIDES:

NEW PERSPECTIVES FOR ELECTROCHEMICAL SOLAR ENERGY CONVERSION.

Helmut Tributsch

Journal of the Electrochemical Society, Vol.

125, No. 7, July 1978, p. 1086-1093.

Holes, photogenerated in d-energy bands of covalent semiconducting layer-type group VI-transition metal dichalcogenides react electrochemically differently from holes generated in semiconductors with valence bands based on p-orbitals (e.g., CdS, ZnO, CdSe, GaAs). They do not constitute broken crystal bonds and do therefore not lead directly to an anodic photodecomposition of the electrode. The chemical character of these holes as missing d-electrons, on the other hand, gives rise to very specific electrochemical surface reactions with electron donors such as I<sup>-</sup>, Br<sup>-</sup>, and even OH<sup>-</sup>, for example. The specific nature of the interfacial charge transfer complexes formed, their advantageous effect on the potential distribution in the electrode surface, and their favorable oxidation potential (in the case of the photoreaction with OH<sup>-</sup> ions), respectively, may be the clue to a promising new approach to several unaccomplished goals of photoelectrochemical research, among them the construction of stable regenerative electrochemical solar cells and the oxidation of water with visible light. Photoelectrochemical measurements performed with MoSe<sub>2</sub> single crystals as well as experiments on solar energy conversion and photoelectrochemical reactions with water induced by visible and near infrared light are described as experimental evidence in support of this finding.

In this review, however, we confine ourselves to the problems of decomposing water into its elements, with emphasis on the semiconductor electrode materials and associated areas such as corrosion and electronic properties. We do not discuss the possible application of semiconductor photoelectrochemistry to promoting other useful chemical reactions or to generating electricity, except as they relate to the problem of the photoelectrolysis of water. We review photoelectrolysis for the materials scientist not familiar with electrochemistry. This provides the basis for specifying the properties the semiconductor must have to be useful. We then discuss the factors important in achieving these properties. This discussion is followed by a summary of published results on electrodes for photoelectrolysis. Finally, the status and future direction of research in this area are discussed.

MODEL SYSTEMS IN PHOTOELECTROCHEMICAL ENERGY  
CONVERSION, by G. W. Murphy.  
Solar Energy, vol. 21, no. 5, 1978, p.403-407.

Abstract—Several model photoelectrochemical energy conversion systems are devised and analyzed, based on properties of liquid junction-solid state semi-conductor photoactive "membranes". The systems are classified in terms of the following output objectives: electric power, short term chemical energy storage, desalted water from a saline source, acid-base production from a saline source, and hydrogen and oxygen from water. Multicompartment photoelectrochemical cells designed to achieve these objectives are made from various combinations of the photoactive component and ion selective membranes. All of the objectives are projected as technically feasible, but only the electric power and desalting are projected as economically feasible based on state-of-the-art technology. The properties of conceptual new solid state membranes needed to meet economic objectives in the other cases are analyzed.

A79-18009 Solar fuels. J. R. Bolton (Western Ontario, University, London, Canada). Science, vol. 202, Nov. 17, 1978, p. 705-711. 31 refs.

The paper is concerned with (1) the thermodynamic and kinetic limits for the photochemical conversion and storage of solar energy as it is received on the earth's surface, and (2) the evaluation of a number of possible photochemical reactions with particular emphasis on the production of solar hydrogen from water. Procedures for generating hydrogen fuel are considered. Topics examined include the general requirements for a fuel-generation reaction, the photochemical reaction, limits on the conversion of light energy to chemical energy, an estimate of chemical storage efficiency, and the water decomposition reaction. M.L.

SOLAR FUELS, THE PRODUCTION OF ENERGY-RICH COMPOUNDS BY  
THE PHOTOCHEMICAL CONVERSION AND STORAGE OF SOLAR  
ENERGY, BY James R. Bolton  
Science, vol. 202, no. 4369, November 1978, p. 705-716

My objective in this article is to define qualitatively and quantitatively the thermodynamic and kinetic limits on the photochemical conversion and storage of solar energy as it is received on the earth's surface, to evaluate a number of possible reactions with particular emphasis on the production of solar hydrogen from water, and to develop a scheme by which hydrogen fuel might be generated.

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NASA Conference on Radiation Energy Conversion, 3d, Ames Research Center, 1978.  
Radiation energy conversion in space...  
cl<sup>1978</sup>. (Card 2)

astronautics and aeronautics ; v.61)  
Includes bibliographies and index.  
ISBN 0-915028-26-4

1. Satellite solar power stations--Congresses. 2. Lasers--Congresses. 3. Space vehicles--Propulsion system--Congresses.

Methods for the Photochemical Utilization of Solar Energy 626  
ROBERT E. SCHWERZEL

McGraw-Hill 1978 Yearbook of Science & Technology

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**Conversion of Sunlight to Chemical Fuel**—Chemical fuels, such as hydrogen and methanol, represent inexpensive high-density sources to meet the world's future energy needs. There have been some recent advances in the use of photoelectrochemical cells to convert sunlight to chemical energy and thus to produce fuels from nitrogen, oxygen, air, and water.

Royal Society of London  
Philosophical Transactions,  
Ser.A, v.295, no.1414

Feb.7,  
1980

SOLAR ENERGY. (A discussion held Nov.15-16,1978.  
Organized by George Porter and William Hawthorne).

N. K. BOARDMAN, F.R.S.

Energy from the biological conversion of solar energy p477

Discussion: M. W. THRING, D. R. JOHNSTON, D. T. SWIFT-HOOK

R. C. RIGHELATO

Microbial production of energy sources from biomass

Discussion: D. O. HALL, SIR WILLIAM HAWTHORNE, F.R.S. p300



Royal Society of London  
Philosophical Transactions,  
Ser.A, v.295, no.1414

Feb.7,  
1980

SOLAR ENERGY. (A discussion held Nov.15-16,1978.  
Organized by George Porter and William Hawthorne).

A. J. NOZIK

Photoelectrochemical cells

P453-470  
The application of photoelectrochemical systems based on photoactive semiconducting electrodes to the problem of solar energy conversion and chemical synthesis is discussed. Three types of cells are described: electrochemical photovoltaic cells (wherein optical energy is converted into electrical energy); photoelectrolysis cells (wherein optical energy is converted into chemical free energy); and photocatalytic cells (wherein optical energy provides the activation energy for exoergic chemical reactions). The critical semiconductor electrode properties for these cells are the band gap, the flat-band potential, and photoelectrochemical stability. No semiconductor electrode material is yet known for which all three parameters are simultaneously optimized. An interesting configurational variation of photoelectrolysis cells, labelled 'photochemical diodes', is described. These diodes comprise cells that have been collapsed into monolithic particles containing no external wires. Recent advances in several areas of photoelectrochemical systems are also described.

THE CHEMICAL CONVERSION OF SUNLIGHT.

Mark S. Wrighton

Technology Review, vol. 79, no. 6, May 1977,  
page 30-37.

Through the use of semiconductors immersed in liquid electrolytes, the energy of the sun can be changed to electricity or used to generate storable fuels.

OPTIMUM EFFICIENCY OF PHOTO GALVANIC CELLS FOR SOLAR ENERGY CONVERSION.

W.J. Albery and M.D. Archer.

Nature, v.270, Dec.1,1977, p.399-402.

*The performance of photogalvanic cells for the direct conversion of solar energy to electrical energy depends on the cell photochemistry, the homogeneous kinetics, the mass transport, the electrode kinetics and the load on the cell. The variation of the power output with the concentrations of the redox couples, their transport and kinetic parameters and the dimensions of the cell is found. The power conversion efficiency of the optimal cell could be as large as 18%, but it is unlikely that all the necessary conditions can be met. A more realistic estimate of the maximum power conversion efficiency that could be achieved from a photogalvanic cell is between 5 and 9%.*

THE DEPENDENCE OF CURRENT OUTPUT OF THE TI-TL  $\text{SnO}_2/\text{Pt}$  IRON-THIONINE PHOTO GALVANIC CELL ON PHOTOSTATIONARY STATE COMPOSITION

Peter D. Wildes, Karen T. Brown, Morton Z. Hoffman and Norman N. Lichtin and Dale E. Hall

Solar Energy  
Vol. 19, no. 5  
p. 579-582

1977.

The possibility of using the iron thionine reaction in the construction of a device for converting solar energy to electricity was first studied by Rabinowitch in 1940[14]. In Rabinowitch's cell, solution in the vicinity of one platinum electrode was illuminated while solution in the vicinity of another similar electrode was kept in the dark. Reaction 3 and the dark reversal of reaction 1 are its exergic power producing reactions. Such a cell may be considered the prototype of a photogalvanic device where "photogalvanic device" is defined as a battery in which cell solution absorbs light to photochemically generate species which, upon back reaction through an external circuit with the aid of suitable electrodes, produce electrical power[15].

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Conference on the Electrochemistry and Physics of Semiconductor Liquid Interfaces under Illumination, Airlie, Va., 1977.

Semiconductor liquid - junction solar cells : proceedings of a Conference on the Electrochemistry and Physics of Semiconductor Liquid Interfaces under Illumination, held at Airlie, Virginia, May 3-5, 1977 / edited by Adam Heller ; sponsored by Office of Naval Research. -- Princeton, N.J. :

During May 3-5, 1977 an international group of scientists working on semiconductor liquid junction solar cells, on photoelectrochemistry of semiconductors and on photoelectrolysis of water met at Airlie, Virginia to discuss the status of these subjects. The topics covered included energetics, losses and storage in semiconductor liquid junction solar cells; theory and chemistry of surfaces at semiconductor-liquid junctions; kinetics and mechanisms of processes occurring at semiconducting photoelectrode-liquid interfaces; stability of semiconducting photoelectrodes; photoelectrodes in non-aqueous solutions; materials for photoelectrochemical solar cells; and photoelectrolysis of water. To put this relatively new solar conversion technology in proper perspective, the state-of-the-art in solid state solar cells was also reviewed. These proceedings cover the lectures delivered at the meeting.

PROPERTIES OF CADMIUM STANNATE THIN FILM ELECTRODES AND THEIR USE IN PHOTOGALVANIC CELLS  
Dale Hall

Journal of the Electrochemical Society, vol. 124, no. 5, May 1977, p. 804 - 807

Cadmium stannate has recently been prepared as sputtered thin films displaying high transparency to visible light and exceptionally low sheet resistance (1). In CdS-Cu<sub>2</sub>S photovoltaic cells, Cd<sub>2</sub>SnO<sub>4</sub> has been used as a transparent, conducting substrate to permit back-wall illumination (2). With suitable postdeposition heat-treatment, Cd<sub>2</sub>SnO<sub>4</sub> films have exhibited sheet resistances of about 1  $\Omega/\square$  and ~90% visible light transmission from 500 to 650 nm. For applications requiring the highest possible conductivity and transparency, Cd<sub>2</sub>SnO<sub>4</sub> appears to offer significant advantages over materials such as indium/tin oxide or tin oxide doped with antimony.

N-TYPE SI-BASED PHOTOELECTROCHEMICAL CELL: NEW LIQUID JUNCTION PHOTOCELL USING A NONAQUEOUS FERRICENIUM/FERROCENE ELECTROLYTE.

K.D. Legg, et al.

Proc. Natl. Acad. Sci. USA, v.74, no.10, Oct.1977, p.4116-4120.

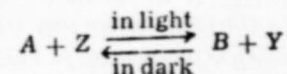
**ABSTRACT** n-Type Si has been shown to serve as a stable photoanode in a cell for the conversion of light to electricity. The other components of the cell are a Pt cathode and an electrolyte consisting of an ethanol solution of [n-Bu<sub>4</sub>N]ClO<sub>4</sub> with a redox couple of ferricenium/ferrocene. Data from a two-compartment cell show that ferrocene is oxidized to ferricenium with 100  $\pm$  2% current efficiency at the Si photoanode. Furthermore, prolonged irradiation of the Si in a one-compartment cell yields constant photocurrent and output characteristics. The maximum open-circuit photopotential is ~700 mV, and the short-circuit quantum yield for electron flow at low light intensity exceeds 0.5. Conversion of monochromatic 632.8-nm light to electricity with ~2% power efficiency at an output voltage of ~200 mV has been sustained. These results represent a stable n-type Si-based photoelectrochemical cell.

PHOTOGALVANIC CELLS II. CURRENT-VOLTAGE AND POWER CHARACTERISTICS

W. J. Albery, and M. D. Archer

Journal of the Electrochemical Society, vol. 124, no. 5, May 1977, p. 688 - 697

A general treatment is developed for the current-voltage characteristics of photogalvanic cells containing two identical electrodes and operating by virtue of the homogeneous reactions



where A, B, and Y, Z are redox couples. The treatment is in terms of the electrode and homogeneous kinetics, the relative magnitudes of the diffusion and reaction layers, and the position of the photostationary state. Power cannot be drawn from the cell if both couples are either highly reversible or highly irreversible. The best performance is obtained if one couple (A, B say) is highly reversible, and the other (Y, Z) highly irreversible, and this case is explored in detail. If the homogeneous kinetics are rapid, we find an important contribution to the current delivered by the cell from catalytic currents due to the presence of Y and Z close to the electrode.

# SENSITIZATION OF AN IRON-THIAZINE PHOTO GALVANIC CELL TO THE BLUE: AN IMPROVED MATCH TO THE INSOLATION SPECTRUM

Peter D. Wildes, David R. Hobart and Norman N. Lichtin

Solar Energy

Vol. 19, no. 5 1977, p. 567-570.

**Abstract**—Sensitization of a totally illuminated thin layer (TI-TL) photogalvanic cell based on the iron-thiazine photoredox reaction has been demonstrated by both current action spectra and enhanced white light output. Singlet sensitization of thionine ( $\lambda_{max} = 601$  nm) and of methylene blue ( $\lambda_{max} = 660$  nm) to wavelengths below 400 nm has been achieved. Photogalvanic output has been obtained upon illumination of a single solution containing two photoredox dyes and three sensitizers with monochromatic light throughout the wavelength range ~375-700 nm. Sensitization with rhodamine 6G considerably enhances cell output under illumination with white light. With some sensitizers, however, white light output is inhibited.

# MECHANISM OF PHOTO GALVANIC EFFECT IN THIONINE-FERROUS SALT SYSTEMS

Kiyotaka Shigehara and Eishun Tsuchida

The Journal of Physical Chemistry

Vol. 81, no. 19, September 22, 1977, p. 1883-1886.

In this paper, the effects of the illumination light intensity, the initial concentration of added ferric ion, and the solvent composition on  $\Delta E$  and  $I$  were examined by using a rapid-scanning cross-illumination apparatus and a double Pt-electrode cell. The active species and the mechanism of electron recycling were also studied.

A78-10624

European Seminar on Biological Solar Energy

Conversion Systems, Grenoble, France, May 9-12, 1977, Proceedings. Seminar sponsored by CNRS, COMES, CEA, DGRST, and INRA. London, International Solar Energy Society, 1977. 164 p. \$11.00.

Agriculture and plant biochemistry topics relevant to biological solar energy conversion systems are discussed. Besides several studies of photosynthesis, research investigations on plant protein, nitrogenase, glycerol production, hydrogen production, methane fermentation, lignocellulose degradation, and electron transfer are reported. Other research deals with plant selection, silvicultural biomass plantations, the use of plant residues to produce energy, and algae characteristics. Also reported are the design of a solar greenhouse, an analysis of post-agricultural energy, a study of village and farm energy systems, and a study of an ocean food and energy farm project.

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Biological solar energy conversion / edited by Akira Mitsui ... [et al.]. — New York : Academic Press, 1977.

xiii, 454 p. : ill. ; 24 cm.

Hydrogen photoevolution in algae, kelp colonies for biomass conversion, and anaerobic fermentation of biomass are discussed. Topics of the papers include the anaerobic metabolism of green algae containing hydrogenase, methane production from sewage and algae, the catalytic activity of hydrogenase in biophotolysis, cell-free hydrogen photoevolution systems, development of mutant *Chlamydomonas reinhardtii* cells possessing oxygen-resistant hydrogenase, the technique of single-turnover flashes for assessing photosynthetic oxygen evolution in algae, an alfalfa bioconversion system, kelp plantations fertilized by deep-ocean water, the design and maintenance of seaweed colonies for biomass conversion.

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Biological solar energy conversion / edited by Akira Mitsui ... [et al.]. — New York : Academic Press, 1977.

xiii, 454 p. : ill. ; 24 cm.

Papers presented at a conference held at the Rosenstiel School of Marine and Atmospheric Science, University of Miami, Nov. 15-18, 1976, under the sponsorship of the United States-Japan Cooperative Science Program, U.S. National Science Foundation, and the Japanese Society for Promotion

# THE POWER CONVERSION EFFICIENCY OF THE GOLD-RHODAMINE B-BOLD PHOTOELECTROCHEMICAL CELL

Terence I. Quickenden and Gek Kim Yim

Solar Energy, vol. 19, no. 3, 1977, p. 283-289

**Abstract**—The power conversion efficiency of the photoelectrochemical cell Au-Rhodamine B-Au was found to be  $(2.4 \pm 0.2) \times 10^{-2}$  per cent under typical operating conditions. A ten-fold improvement could be expected from constructional modifications, but further increases in efficiency would require changes in the cell chemistry. The low power conversion efficiency can be related to a low  $(4.7 \times 10^{-2}$  per cent) efficiency for the production of the open circuit photovoltage; a low  $(2.2 \times 10^{-2}$  per cent) quantum efficiency for the production of the short circuit current; and to markedly non-rectangular voltage-current characteristics. The deviations from a rectangular relationship and the low efficiency of current production arise from mass-transport limitations rather than from ohmic losses or activation polarisation. The low voltage efficiency probably arises from inefficiencies in the photochemical and electron transfer steps which lead to photovoltage production. The limitations of this type of cell as a solar energy conversion device are discussed.



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International Conference on the Photochemical  
Conversion and Storage of Solar Energy, 1st,  
University of Western Ontario, 1976.

Solar power and fuels : proceedings of  
the First International Conference on the  
Photochemical Conversion and Storage of  
Solar Energy, London, Canada, August 24-28,  
1976 / edited by James R. Bolton ; sponsored  
by the Photochemistry Unit, University of  
Western Ontario and the Department of Chem-

A78 27889      Solar power and fuels, Proceedings of the First  
International Conference on the Photochemical Conversion and  
Storage of Solar Energy, University of Western Ontario, London,  
Canada, August 24-28, 1976. Conference sponsored by the Uni-  
versity of Western Ontario and Boston University. Edited by J. R.  
Bolton (Western Ontario, University, London, Canada). New York,  
Academic Press, Inc., 1977. 268 p. \$13.50. (For individual items see  
A78 27890 to A78 27896)

The various possibilities for the photochemical conversion and  
storage of solar energy are examined. Attention is given to the  
chemical utilization of solar energy through systems in which the  
quanta of radiation are not degraded to heat but are utilized in  
atomic or molecular systems undergoing chemical changes. Topics of  
interest include power generation by photoelectrolysis, photo-  
galvanic processes, photochemical production of a fuel, and ultrathin  
barriers in solar energy conversion. Organic molecular energy storage  
reactions are described along with the role of photosynthesis in  
energy production. S.D.

A78 10623      Conference on Capturing the Sun Through  
Bioconversion, Washington, D.C., March 10-12, 1976, Proceedings.  
Conference sponsored by ERDA, EPA, U.S. Department of Agricul-  
ture, FEA, Council on Environmental Quality, NSF, U.S. Depart-  
ment of Commerce, DOD, DI, U.S. Department of State, et al.  
Washington, D.C., Bio-Energy Council, 1976. 872 p. \$18.

Several subjects relevant to solar energy bioconversion are  
discussed. General surveys of the gas deficit, the ecology of  
bioconversion, and congressional perspective are presented. Biomass  
sources are considered with attention to urban and industry wastes,  
agricultural and forestry wastes, land and fresh water energy farming,  
and ocean farming. Bioconversion processes and products are  
examined in terms of gaseous fuels, liquid fuels, solid fuels, related  
products, and long-range concepts. Overall impacts are analyzed from  
the viewpoint of technology assessment, economic/social impacts,  
environmental impacts, and international aspects. M.L.

# SOLAR - THERMAL ELECTRIC SYSTEMS

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- Intersociety Energy Conversion Engineering Conference, 14th, Boston, 1979.  
Proceedings of the 14th Intersociety Energy Conversion Engineering Conference, Boston, Massachusetts, August 5-10, 1979. -- Washington, D. C. : American Chemical 799003  
Optical-Thermal Performance Analysis for Fixed Mirror-Distributed Focus Solar-Thermal-Electric Power System, L.D. Clements and J.D. Reichert ..... 111  
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Projected Techno-Economic Improvements for Advanced Solar Thermal Power Plants, T. Fujita, R. Manvi and E.J. Roschke ..... 39
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- Intersociety Energy Conversion Engineering Conference, 14th, Boston, 1979.  
Proceedings of the 14th Intersociety Energy Conversion Engineering Conference, Boston, Massachusetts, August 5-10, 1979. -- Washington, D. C. : American Chemical 799011  
Advanced Solar Thermal Technology: Potential and Progress, L.P. Leibowitz and E. Hanseth ..... 66  
799012  
Solar Thermal Systems Long-Term Performance Predictions Using Closed-Form Solutions, D.K. Anand, R.B. Abarcar and S.R. Venkatewaran ..... 72

THE IMPACT OF A CONCEPTUAL SOLAR THERMAL ELECTRIC CONVERSION PLANT ON REGIONAL METEOROLOGICAL CONDITIONS: A NUMERICAL STUDY  
Chandrakant M. Bhumraikar, Jill Williams and Arthur Slemmons

Solar Energy, vol. 23, no. 5, 1979, pp. 393-403.

**Abstract**—A two-dimensional, mesoscale model of the atmosphere that incorporates hydrodynamic, thermodynamic, and microphysical processes has been applied to simulate the impact on regional weather of a solar thermal electric conversion (STEC) installation in southern Spain. The STEC plant is conceptualized to occupy an area of 1,000 km<sup>2</sup> with heliostats covering 25 per cent of the total power plant area. It is assumed to use wet natural draft cooling towers for dissipating waste heat into the atmosphere.

The 2-D model is applied to a STEC facility that covers a distance of 32 km in the horizontal with heliostats installed in the middle over a distance of 8 km. The model has been integrated for 9 hr of real time for both typical summer and winter conditions.

The results of integration for summer indicate that a STEC installation of the above size has considerable potential for modifying regional weather. Clouds formed after 5 hr of real-time integration and persisted until the end of the integration; rainfall also occurred. In contrast, clouds did not form until 7 hr of real-time integration without the installation and were more sporadic and transient; rainfall was much less.

The results for winter conditions do not show any cloud formation after 9 hr of real-time integration. This difference between summer and winter cases is attributed to the very strong winds used as initial conditions for the winter simulation.

THE AMPERE-HOUR EFFICIENCY OF PHOTOVOLTAIC SOLAR GENERATORS. D. G. S. Chuah.

Energy Conversion and International Journal, vol 19, no 3, 1979, p. 177-180.

**Abstract**—The charging power and discharge power of two photovoltaic solar generators are measured simultaneously with the sunshine hours. A comparison of these two powers shows that there is sufficient power under the available local sunshine for lighting purposes. The ampere-hour efficiency of these generators is compared with that of lead acid and nickel-iron cells. A 10% difference in the ampere-hour efficiencies for the two generators is observed.



PHOTOVOLTAICS AND SOLAR THERMAL CONVERSION  
TO ELECTRICITY: STATUS AND PROSPECTS  
Marshall E. Alper

Journal of Energy, vol. 3, no. 5, Sept/Oct 1979,  
p. 263-270.

Programs for developing the technologies and stimulating the commercial utilization of photovoltaic and thermal power systems for converting sunlight into electricity constitute two major elements of the U.S. Department of Energy's solar program. Options include flat-plate and concentrating photovoltaics, and central and modular thermal systems with two-axis tracking and point focus. The technology development activities are all directed toward meeting the technical as well as the cost-performance goals in the 1983-1988 time period. In addition, field tests and applications experiments are being conducted. Prospects for achieving the technical and cost-performance goals are assessed in this survey. Prospects for commercial utilization on a scale large enough to make a significant impact on national energy supply are more difficult to assess; however, the advantages and drawbacks associated with using these solar technologies are considered and compared to a set of conditions—economic, environmental, and social—that could favor the commercial use of these solar systems.

A79-51755 \* Solar parabolic dish thermal power systems - Technology and applications. J. W. Lucas and A. T. Marriott (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 166-175. 19 refs. Research sponsored by the U.S. Department of Energy.

Activities of two projects at JPL in support of DOE's Small Power Systems Program are reported. These two projects are the Point Focusing Distributed Receiver (PFDR) Technology Project and the Point Focusing Thermal and Electric Applications (PFTEA) Project. The PFDR Technology Project's major activity is developing the technology of solar concentrators, receivers and power conversion subsystems suitable for parabolic dish or point focusing distributed receiver power systems. Other PFDR activities include system integration and cost estimation under mass production, as well as the testing of the hardware. The PFTEA Project's first major activity is applications analysis, that is seeking ways to introduce PFDR systems into appropriate user sectors. The second activity is systems engineering and development wherein power plant systems are analyzed for specific applications. The third activity is the installation of a series of engineering experiments in various user environments to obtain actual operating experience. (Author)

32862 Solar electricity. Palz, W. pp 519-538 of Solar energy. Geneva, Switzerland; World Meteorological Organization (1977). From UNESCO/WMO solar energy symposium, Geneva, Switzerland (30 Aug 1976).

The two basic technologies for converting the sun's radiation into useful electric power are reviewed: (a) direct conversion by transfer of radiative energy onto the electrons of a solid and (b) conversion of radiation into heat and secondarily into electricity in a thermodynamic process. The spectrum of conversion processes is summarized. (MHR)

TPV MANAGEMENT APPROACH TO HIGH-RISK RESEARCH.  
DPRI Journal, vol 4, no 3, April 1979, p. 19-22.

Thermophotovoltaic conversion  
is a new idea for electricity  
generation. But as an unproved  
concept, its development is  
subject to constant scrutiny by  
teams of experts brought  
together by EPRI.

A79-51733 \* Projected techno-economic improvements for advanced solar thermal power plants. T. Fujita, R. Marvi, and E. J. Roschke (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 39-44. 25 refs. Research sponsored by the U.S. Department of Energy.

The projected characteristics of solar thermal power plants (with outputs up to 10 MWe) employing promising advanced technology subsystems/components are compared to current (or pre-1985) steam-Rankine systems. Improvements accruing to advanced technology development options are delineated. The improvements derived from advanced systems result primarily from achieving high efficiencies via solar collector systems which (1) capture a large portion of the available insolation and (2) concentrate this captured solar flux to attain high temperatures required for high heat engine/energy conversion performance. The most efficient solar collector systems employ two-axis tracking. Attractive systems include the central receiver/heliostat and the parabolic dish. (Author)

A79-38198 \* # Selection and development of small solar thermal power applications. S. A. Bluhm, T. J. Kuehn, and R. M. Gurfield (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1005. 7 p. 7 refs. Research sponsored by the U.S. Department of Energy.

The paper discusses the approach of the JPL Point Focusing Thermal and Electric Power Applications Project to selecting and developing applications for point focusing distributed receiver solar thermal electric power systems. Six application categories are defined. Results of application studies of U.S. utilities are presented. The economic value of solar thermal power systems was found to range from \$900 to \$2100/kWe in small community utilities of the Southwest. (Author)

# REAL-TIME COMPUTER CONTROL OF FIVE MEGAWATTS OF SOLAR THERMAL ENERGY

E. D. Thalhammer

ISA Transactions, vol 18, no. 4, 1979, p. 3-8.

The Central Receiver Test Facility (CRTF) operates under the control of a nine-machine distributed minicomputer network. The prime functions of this network are heliostat controls, heat rejection system controls, and data acquisition. This paper describes the control computer. This computer's main tasks are: (1) the sun position calculation, (2) automatic heliostat command execution, (3) graphic display of heliostat status and selected items of tower and boiler control data, (4) operator control of the heliostat command cycle, (5) heliostat alarm handling, and (6) the permanent recording of all test parameters that fully describe the experiment performed. The control system is capable of directing 5 MW of thermal energy at any point within 327 m of the solar receiver tower. Also, the procedures and checking performed by the computers to insure personnel and facility safety are described here.

**N79-33577\*** McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.

**PHASE 1 OF THE FIRST SMALL POWER SYSTEM EXPERIMENT (ENGINEERING EXPERIMENT NO. 1). VOLUME 2: SYSTEM CONCEPT SELECTION Final Report**

R. J. Holl May 1979 312 p. Prepared for JPL 5 Vol.

(Contract NAS7-100; JPL 955117)

(NASA-CR-162373; MDC-G7833-Vol-2) Avail: NTIS HC A14/MF A01 CSCL 10A

The development of a modular solar thermal power system for application in the 1 to 10 MWe range is presented. The system is used in remote utility applications, small communities, rural areas, and for industrial uses. Systems design and systems optimization studies are conducted which consider plant size, annual capacity factors, and startup time as variables. Investigations are performed on the energy storage requirements and type of energy storage, concentrator design and field optimization, energy transport, and power conversion subsystems. The system utilizes a Rankine cycle, an axial flow steam turbine for power conversion, and heat transfer sodium for collector fluid. AWH.

**A79-37890**

Large scale solar thermal power generation. B. McNelis (General Technology Systems, Ltd., Hounslow, Middx., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 264-267. 21 refs.

Solar power generation options are reviewed and particular consideration is given to the central receiver system. It is noted that a 100 MW plant in a sunny region would employ about 15,000 heliostats, each with an area of 35 sq m, a central tower about 280 m high, and would cover an area of about 1.2 sq km. The plant would operate for about 6-8 hours per day with a conversion efficiency of about 20%. B.J.

**A79-38894\*** Solar Stirling system development. J. W. Stearns, Jr., Y. S. Won, P. T. Poon, R. Das, and E. Y. Chow (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1009. 18 p. 15 refs. Research sponsored by the U.S. Department of Energy.

A low cost, high-efficiency dish Stirling solar thermal-electric power system is being developed for test in 1981. System components are the solar concentrator, receiver, fossil fuel combustor, thermal energy storage (TES), engine generator, and power processing. System conceptualization is completed and design is in progress. Two receiver alternatives are being evaluated, a direct coupled receiver-engine configuration with no TES and a heat pipe receiver with TES. System cost projections are being made. Goals for the system development task are (1) to develop an advanced dish Stirling technology, utilizing a team of industrial contractors, (2) to demonstrate that technology at the system level, and (3) to determine how to achieve low production cost. (Author)

## SOLAR ELECTRIC GENERATING SYSTEM RESOURCE REQUIREMENTS. R. C. Enger, and H. Weichel.

Solar Energy, vol 23, no 3, 1979, p. 255-261.

**Abstract** - The potential consumption of materials, land, water, manpower, energy, and money by four proposed solar electric generating systems: a terrestrial solar thermal, a terrestrial photovoltaic, an orbiting solar reflector, and a satellite solar power system are analyzed. The evaluation demonstrated that, per megawatt of electrical generating capacity, the terrestrial solar thermal system would require less manpower, less energy of production, and less money than would the extra-terrestrial systems.

## SECOND-LAW ANALYSIS OF SOLAR-THERMAL PROCESSES. J. F. Kreider.

Energy Research vol 3, no 4, October-December 1979, p. 325-331.

The second law of thermodynamics provides an analytic framework for the assessment of the potential displacement of fossil fuels by solar energy. The most promising areas are those which have entropy levels corresponding to the entropy level of the solar resource as converted to heat in various types of solar collectors. Since the entropy of solar heat can be partitioned by the means of collection—e.g., by the collector concentration ratio—solar can be matched much more precisely to many tasks at temperatures up to 300°C than can fossil fuels which are low entropy sources now widely misused for high entropy tasks.

HEAT TRANSFER - SAN DIEGO 1979. Robert W. Lyczkowski, ed. (Comprised of papers presented at AIChE 18th National Heat Transfer Conf. held San Diego, Calif., Aug.5-8,1979).

FIELD SELECTION FOR A 100MW(e) LINE FOCUS SOLAR CENTRAL POWER STATION

J. M. Neill and J. R. Schuster 297

A systems evaluation study was conducted to enable selection of a heat transport and storage fluid for a 100 MW(e) line focus solar central power station. The study, based on the General Atomic Company Fixed Mirror Solar Concentrator, addressed cost, technical, and marketing issues and resulted in the selection of draw salt over Therminol 88 and sodium.

N79-33573\*# Ford Aerospace and Communications Corp., Newport Beach, Calif. Aeronautics Div.

PHASE 1 OF THE FIRST SOLAR SMALL POWER SYSTEM EXPERIMENT (EXPERIMENTAL SYSTEM NO. 1). VOLUME 1: TECHNICAL STUDIES FOR SOLAR POINT-FOCUSING, DISTRIBUTED COLLECTOR SYSTEM, WITH ENERGY CONVERSION AT THE COLLECTOR. CATEGORY C Final Report

T. B. Clark, ed. 5 May 1979 294 p. Prepared for JPL 3 Vol

(Contract NAS7-100, JPL 955115)

(NASA CR-162369, U-6529 Vol 1)

Avail. NTIS

HC A13/MF A01 CSCL 10A

The technical and economic feasibility of a solar electric power plant for a small community is evaluated and specific system designs for development and demonstration are selected. All systems investigated are defined as point focusing, distributed receiver concepts, with energy conversion at the collector. The preferred system is comprised of multiple parabolic dish concentrators employing Stirling cycle engines for power conversion. The engine, AC generator, cavity receiver, and integral sodium pool boiler/heat transport system are combined in a single package and mounted at the focus of each concentrator. The output of each concentrator is collected by a conventional electrical distribution system which permits grid connected or stand alone operation, depending on the storage system selected. K.L.

SOLAR FROM GERMANY, by David Scott.

Popular Science, vol. 214, no. 2, Feb. 1979, p.76-77.

N80 12563# Sandia Labs., Albuquerque, N. Mex. Systems Analysis Div.

EFFECT OF OPERATING TEMPERATURES ON THE COST OF ENERGY FROM SOLAR THERMAL ELECTRIC POWER PLANTS

L. I. Lukens Jul 1979 88 p. refs

(Contract EY-76-C-04-0789)

(SAND-79-0801) Avail. NTIS HC A05/MF A01

The operating temperature of a solar thermal electric power plant controls the efficiency of the collector field, the efficiency of the power generation system and the cost of the thermal energy storage system. The effect of these three items, as temperature is varied, on the annualized cost of energy produced by the system was evaluated for both stand-alone solar and solar diesel hybrid power plants. The type of solar power plant considered was one using a linear focus distributed collector field and a Rankine cycle power generation system. Systems using different collector performance models, Rankine cycle working fluids and thermal energy storage concepts were included in the evaluation.

DOE

A80-18586\*# Small solar thermal electric power plants with early commercial potential. H. E. Jones, D. J. Brantz, R. N. Clayton, H. H. Heiges, and A. C. Ku (General Electric Co., Schenectady, N.Y.). American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Dec. 2-7, 1979, Paper 79-WA-Sol 9. 8 p. 5 refs. Members, \$150; nonmembers, \$300. Contract No. JPL 955116

Cost-effective small solar thermal electric power plants (1- to 10 MW nominal size) offer an attractive way of helping the world meet its future energy needs. The paper describes the characteristics of a conceptual near term plant (about 1 MW) and a potential 1990 commercial version. The basic system concept is one in which steam is generated using two-axis tracking, parabolic dish, and point-focusing collectors. The steam is transported through low loss piping to a central steam turbine generator unit where it is converted to electricity. The plants have no energy storage and their output power level varies with the solar insolation level. This system concept, which is firmly based on state of the art technology, is projected to offer one of the fastest paths for U.S. commercialization of solar thermal electric power plants through moderate technology advances and mass production.

(Author)

32811 (NTISUB/B/024-76/003) Solar thermal energy utilization: a bibliography with abstracts. Quarterly update, July-September 1976. (New Mexico Univ., Albuquerque (USA). Technology Application Center). Mar 1977. 142p. (TAC/ST-76-608). NTIS, PC A07/MF A01.

The bibliography contains citations on the following subjects: development, solar and atmospheric radiation, material properties, components, space heating and cooling, process heat, and power generation. An author index and a permuted title/subject term index are included. (MHR)



**HEAT TRANSFER - SAN DIEGO 1979.** Robert W. Lyczkowski, ed. (Comprised of papers presented at AIChE 18th National Heat Transfer Conf. held San Diego, Calif., Aug. 5-8, 1979).

**PERFORMANCE CHARACTERISTICS OF A COMMERCIALY AVAILABLE POINT-FOCUS, SOLAR POWER SYSTEM.....M. Bohn 282**

The performance of a commercially available solar electric power system is described in terms of instantaneous electrical power output for a given insolation and electrical energy production per day.

Receiver thermal loss coefficient and concentrator optical efficiency are measured and system performance is then given with steam cycle efficiency and electrical generator efficiency as parameters. System performance is limited by a relatively low optical efficiency of 44%. For peak insolation, this collector delivers 9.2 kW<sub>th</sub> to the steam engine, representing 35% of the solar input.

**N79 23503\*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena  
TECHNO-ECONOMIC PROJECTIONS FOR ADVANCED  
SMALL SOLAR THERMAL ELECTRIC POWER PLANTS TO  
YEARS 1990-2000**

T. Fujita, R. Manvi, E. J. Roschke, N. El-Gabalawi, G. Herrera, T. J. Kuo, and K. H. Chen. 15 Nov. 1979. 166 p. refs. Prepared for DOE.

(Contract NAS7-100, JPL Proj. 5102-99)  
(NASA-CR-158519, JPL-PUB-79-25, DOE/JPL-1060-4) Avail.  
NTIS HC A08/MF A01 CSCL 10B

Advanced technologies applicable to solar thermal electric power systems in the 1990-200 time-frame are delineated for power applications that fulfill a wide spectrum of small power needs with primary emphasis on power ratings less than 10MWe. Projections of power system characteristics (energy and capital costs as a function of capacity factor) are made based on development of identified promising technologies and are used as the basis for comparing technology development options and combinations of these options to determine developmental directions offering potential for significant improvements. Stirling engines, Brayton/Rankine combined cycles and storage/transport concepts encompassing liquid metals, and reversible reaction chemical systems are considered for two-axis tracking systems such as the central receiver or power tower concept and distributed parabolic dish receivers which can provide efficient low cost solar energy collection while achieving high temperatures for efficient energy conversion. Pursuit of advanced technology across a broad front can result in post-1985 solar thermal systems having the potential of approaching the goal of competitiveness with conventional power systems. A.R.H.

**N79 33575\*# Ford Aerospace and Communications Corp., Newport Beach, Calif. Aeronutronic Div.**

**PHASE 1 OF THE FIRST SOLAR SMALL POWER SYSTEM EXPERIMENT (EXPERIMENTAL SYSTEM NO. 1).**

**VOLUME 3: APPENDIX E - N Final Report**

T. B. Clark, ed. 5 May 1979. 187 p. Prepared for JPL. 3 Vol.

(Contract NAS7-100, JPL-955115)

(NASA-CR-162371, U-6529 Vol. 3)

Avail. NTIS

HC A09/MF A01 CSCL 10A

The design of a solar electric power plant for a small community is reported. Topics covered include: (1) control configurations and interface requirements for the baseline power system; (2) annual small power system output; (3) energy requirements for operation of the collectors and control building; (4) life cycle costs and reliability predictions; (5) thermal conductivities and costs of receiver insulation materials; (6) transient thermal modelling for the baseline receiver/thermal transport system under normal and inclement operating conditions; (7) high temperature use of sodium; (8) shading in a field of parabolic collectors; and (9) buffer storage materials. K.L.

**N79 33578\*# McDonnell Douglas Astronautics Co., Huntington Beach, Calif.**

**PHASE 1 OF THE FIRST SMALL POWER SYSTEM EXPERIMENT (ENGINEERING EXPERIMENT NO. 1). VOLUME 3: EXPERIMENTAL SYSTEM DESCRIPTIONS Final Report**

R. J. Holl. May 1979. 361 p. Prepared for JPL. 5 Vol.

(Contract NAS7-100, JPL-955117)

(NASA-CR-162374, MDC-G7833-Vol. 3)

Avail. NTIS

HC A18/MF A01 CSCL 10A

The design and development of a modular solar thermal power system for application in the 1 to 10 MWe range is described. The system consists of five subsystems: the collector, power conversion, energy transport, energy storage, and the plant control subsystem. The collector subsystem consists of concentrator, receiver, and tower assemblies. The energy transport subsystem uses a mixture of salts with a low melting temperature to transport thermal energy. A steam generator drives a steam Rankine cycle turbine which drives an electrical generator to produce electricity. Thermal and stress analysis tests are performed on each subsystem in order to determine the operational reliability, the minimum risk of failure, and the maintenance and repair characteristics. A.W.H.

**A79 37299**

**High temperature solar thermoelectric genera-**

**tor.** K. P. Suleetka (University of Wales Institute of Science and Technology, Cardiff, Wales). *Applied Energy*, vol. 5, Jan. 1979, p. 53-59. 6 refs. Research supported by the Science Research Council.

The performance of a sintered Si-Ge thermoelectric generator is assessed by computing power output per unit area and the efficiency of thermoelectric conversion. Previously developed high temperature solar energy absorbers were used. The power output and efficiency are considerably improved by using a water- or vapor-cooled heat sink in place of a radiative heat sink. The power density in the thermoelectric generator compares well with those in photovoltaic heterojunction cells using concentrated solar energy. (Author)

DEVELOPING MASTER CONTROLS FOR A CENTRAL RECEIVER SOLAR POWER PLANT, by D.M. Darsey, M.A. Soderstrand, R.C. Rountree, R.R. Sheahan, and C.P. Winarski. Instrumentation Technology, vol. 26, no. 3, March 1979, p.41-45.

*A distributed control system, comprising conventional and computerized modules, is being developed for use in a pilot central receiver solar power plant. The configuration has the capability to gather data for evaluation as well as to provide central supervision and coordination.*

A80-18588 \* # The effects of regional insolation differences upon advanced solar thermal electric power plant performance and energy costs. A. F. Latta, J. M. Bowyer, and T. Fujita (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Dec. 2-7, 1979, Paper 79-WA/Sol 15. 10 p. 11 refs. Members, \$1.50; nonmembers, \$3.00. Contract No. DE AIO1-79ET-20307.

This paper presents the performance and cost of four 10-MWe advanced solar thermal electric power plants sited in various regions of the continental United States. Each region has different insolation characteristics which result in varying collector field areas, plant performance, capital costs, and energy costs. The paraboloidal dish, central receiver, cylindrical parabolic trough, and compound parabolic concentrator (CPC) comprise the advanced concepts studied. This paper contains a discussion of the regional insolation data base, a description of the solar systems' performances and costs, and a presentation of a range for the forecast cost of conventional electricity by region and nationally over the next several decades.

(Author)

N79-33574\*# Ford Aerospace and Communications Corp., Newport Beach, Calif. Aeronutronic Div.  
PHASE 1 OF THE FIRST SOLAR SMALL POWER SYSTEM EXPERIMENT (EXPERIMENTAL SYSTEM NO. 1).  
VOLUME 2: APPENDIX A - D Final Report  
T. B. Clark, ed. 5 May 1979. 279 p. Prepared for JPL 3 Vol.

(Contract NAS7-100, JPL 955115)

(NASA CR-162370, U-6529-Vol 2)

HC A13/MF A01 CSCL 10A

Avail. NTIS

Recommended conceptual designs for the baseline solar concentrator and electrical subsystems are defined, and trade offs that were evaluated to arrive at the baseline systems are presented. In addition, the developmental history of the Stirling engine is reviewed, the U4 configuration is described, and a Stirling engine heat pipe system is evaluated for solar application where sodium vapor is used as the heat source. An organic Rankine cycle engine is also evaluated for solar small power system application.

K.L.

N80-16503# Department of Energy, Washington, D. C.  
ENVIRONMENTAL DEVELOPMENT PLAN: SOLAR THERMAL POWER SYSTEMS

Aug 1979. 45 p. refs.

(DOE/TF-G035) Avail. NTIS HC A03/MF A01

The goals of the program and potential environmental, health, safety, and socioeconomic impacts relevant to solar thermal power systems (STPS), particularly those sited in the Southwest are discussed. These impacts are screened for key issues, i.e. those issues considered to be the most serious in nature, that have near term importance to the program, and for which current knowledge of effects and control is inadequate. A management plan is then presented for conducting and coordinating environmental research in concert with the technology development effort to ensure that identified environmental issues are resolved prior to significant public deployment of the technology. Key environmental concerns associated with the development and deployment of STPS were identified in the following subject areas: (1) site selection (including the question of water availability); (2) ecological and microclimatic effects; (3) working fluid handling and release modes; and (4) misdirected solar radiation.

DOE

36078 (DOE/ET-0078) Solar thermal power systems. Program summary. (Department of Energy, Washington, DC (USA). Office of Energy Technology; Department of Energy, Washington, DC (USA). Office of Conservation and Solar Applications). Dec 1978. 280p. Dep. NTIS, PC A13/MF A01.

Each of DOE's solar Thermal Power Systems projects funded and/or in existence during FY 1978 is described and the status as of September 30, 1978 is reflected. These projects are divided as follows: small thermal power applications, large thermal power applications, and advanced thermal technology. Also included are: 1978 project summary tables, bibliography, and an alphabetical index of contractors. (MHR)

## TURNING TO THE SUN FOR POWER.

Electric Power Research Institute, vol 4, no 5, June 1979, p. 18-22.

One key to economical solar-thermal power is an efficient receiver. EPRI has two promising designs under test.

TK	Intersociety Energy Conversion Engineering	
2896	Conference, 14th, Boston, 1979.	
.155	Proceedings of the 14th Intersociety	
1979	Energy Conversion Engineering Conference,	
	Boston, Massachusetts, August 5-10, 1979.	
	-- Washington, D. C. : American Chemical	
	Society, c1979.	
799021	<b>Dynamic Simulation of a Sodium-Cooled,</b>	
	<b>Advanced Central Receiver Solar/Electric</b>	
	<b>Power Plant, W. Wilcox and J. Beckman</b> . . . . .	118 <sup>1</sup>
799022	<b>Solar Production of Industrial Process Steam,</b>	
	<b>J. Cherne, G. Gelb and D. Pinkerton</b> . . . . .	124 <sup>1</sup>
799023	<b>Dynamics and Control of Stirling Engines in a</b>	
	<b>15 kWe Solar Electric Generation Concept,</b>	
	<b>R.S.L. Das and K.A. Bahrami</b> . . . . .	133
799024	<b>Turbine Sizing of a Solar Thermal Power</b>	
	<b>Plant, R. Manvi and T. Fujita</b> . . . . .	139
799025	<b>Sandia Laboratories Operational Experience</b>	
	<b>with Small Heat Engines in Solar Thermal</b>	
	<b>Power Systems, J.P. Abbin, Jr.</b> . . . . .	143
799028	<b>A Simple Leak-Proof Heat Exchanger for Use</b>	
	<b>in Solar Energy Systems, B. Larkin and J.</b>	
	<b>Ramsden</b> . . . . .	155
799029	<b>A New Solar Thermal Receiver Utilizing a</b>	
	<b>Small Particle Heat Exchange, A.J. Hunt</b> . . . . .	159
799034	<b>Solar Point-Focusing Thermal Power Systems</b>	
	<b>Technology and Applications, J.W. Lucas and</b>	
	<b>A.T. Marriott</b> . . . . .	166
799035	<b>Solar Central Receiver Program, L. Tallerico</b> .	176
799036	<b>Solar One Project: A 10-Megawatt Solar</b>	
	<b>Thermal Central Receiver Pilot Plant, R.N.</b>	
	<b>Schweinberg and J.N. Reeves</b> . . . . .	181

799038	<b>Comparative Ranking of 0.1 to 10 MWe Solar</b>	
	<b>Thermal Power Systems, J.P. Thornton, K.C.</b>	
	<b>Brown, J.G. Finegold and F.A. Herlevich</b> . . . . .	190
799040	<b>A Combined Cycle for Solar-Fossil Hybrid</b>	
	<b>Power Generation, E.Y. Lam and J.H. Westsik</b> . . . . .	203
799041	<b>Solar Thermal Power Plants in Small</b>	
	<b>Utilities: An Economic Impact Analysis, S.A.</b>	
	<b>Bluhm, R.R. Ferber and L.G. Mayo</b> . . . . .	207

A80-18584 \* # A solar thermal electric power plant for small communities. R. J. Holt (McDonnell Douglas Astronautics Co., Huntington Beach, Calif.). *American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Dec. 2-7, 1979. Paper 79-WA/Sol-7.* 12 p. 9 refs. Members, \$1.50; nonmembers, \$3.00. Research sponsored by the U.S. Department of Energy and NASA.

A solar power plant has been designed with a rating of 1000-kW electric and a 0.4 annual capacity factor. It was configured as a prototype for plants in the 1000 to 10,000-kW size range for application to small communities or industrial users either grid connected or isolated from a utility grid. A small central receiver was selected for solar energy collection after being compared with alternative distributed collectors. Further trade studies resulted in the selection of Hitec (heat transfer salt composed of 53 percent KNO<sub>3</sub>, 40 percent NaNO<sub>2</sub>, 7 percent NaNO<sub>3</sub>) as both the receiver coolant and the sensible heat thermal storage medium and the steam Rankine cycle for power conversion. The plant is configured with road-transportable units to accommodate remote sites and minimize site assembly requirements. Results of the analyses indicate that busbar energy costs are competitive with diesel-electric plants in certain situations, e.g., off-grid, remote regions with high insolation. Sensitivity of energy costs to plant power rating and system capacity factor are given. (Author)

N79-33579\*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.

**PHASE 1 OF THE FIRST SMALL POWER SYSTEM EXPERIMENT (ENGINEERING EXPERIMENT NO. 1). VOLUME 4: COMMERCIAL SYSTEM DEFINITION Final Report**

R. J. Holt May 1979 113 p. Prepared for JPL 5 Vol

(Contract NAS7-100, JPL-955117)

(NASA-CR 162375, MDC-G7833-Vol-4) Avail NTIS HC A06/MF A01 CSCL 10A

The development and design of a modular solar thermal power system for application in the 1 to 10 MWe range is described. The system is used in remote utility applications, small communities, rural areas, and for industrial uses. The operational reliability, the minimum risk of failure, and the maintenance and repair characteristics are determined and the commercial system design is defined. A W H

**N80-14488\*** # Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**APPLICATION OF FIELD-MODULATED GENERATOR SYSTEMS TO DISPERSED SOLAR THERMAL ELECTRIC GENERATION**

R. Ramakumar 15 Aug. 1979 94 p refs Sponsored in part by DOE

(Contract NAS7-100; JPL Proj. 5102-136)  
(NASA-CR-162536; JPL-Pub-79-83; DOE/JPL-1060-25) Avail:  
NTIS HC A05/MF A01 CSCL 10A

The state-of-the-art of field modulated generation system (FMGS) is presented, and the application of FMGS to dispersed solar thermal electric generation is discussed. The control and monitoring requirements for solar generation system are defined. A comparison is presented between the FMGS approach and other options and the technological development needs are discussed.

R.E.S.

**N79-33576\*** # McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.

**PHASE 1 OF THE FIRST SMALL POWER SYSTEM EXPERIMENT (ENGINEERING EXPERIMENT NO. 1). VOLUME 1: EXECUTIVE SUMMARY Final Report**

R. J. Holl May 1979 69 p Prepared for JPL 5 Vol.

(Contract NAS7-100; JPL-955117)

(NASA-CR-162372; MDC-G7833-Vol-1) Avail: NTIS  
HC A04/MF A01 CSCL 10A

The development of a modular solar thermal power system for application in the 1 to 10 MWe range is presented. The system is used in remote utility applications, small communities, rural areas, and for industrial uses. Investigations are performed on the energy storage requirements and type of energy storage, concentrator design and field optimization, energy transport, and power conversion subsystems. The system utilizes a Rankine cycle, an axial flow steam turbine for power conversion, and heat transfer sodium for collector fluid.

A.W.H.

**32812** (NTISUB/B/024-76/004) Solar thermal energy utilization: a bibliography with abstracts. Quarterly update, October-December 1976. (New Mexico Univ., Albuquerque (USA). Technology Application Center). Mar 1977. 130p. (TAC/ST-76-609). NTIS, PC A07/MF A01.

This bibliography contains citations on the following subjects: development, solar and atmospheric radiation, material properties, components, space heating and cooling, process heat, and power generation. An author index and a permuted title/subject term index are included. (MHR)

**A80-18553\*** # Optimization of a point-focusing, distributed receiver solar thermal electric system. R. L. Pons (Ford Aerospace and Communications Corp., Aeronutronic Div., Newport Beach, Calif.). *American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Dec. 2-7, 1979, Paper 79-WA/Sol-17*. 10 p. Members, \$1.50; nonmembers, \$3.00. Contract No. JPL-955115.

This paper presents an approach to optimization of a solar concept which employs solar-to-electric power conversion at the focus of parabolic dish concentrators. The optimization procedure is presented through a series of trade studies, which include the results of optical/thermal analyses and individual subsystem trades. Alternate closed-cycle and open-cycle Brayton engines and organic Rankine engines are considered to show the influence of the optimization process, and various storage techniques are evaluated, including batteries, flywheels, and hybrid-engine operation.

(Author)

**A79-51739\*** Advanced solar thermal technology - Potential and progress. L. Leibowitz and E. Hanseth (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: *Inter-society Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1*. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 66-71. 6 refs. Research sponsored by the U.S. Department of Energy.

The advanced thermal power technology program which develops and applies advanced technology for improved solar thermal energy subsystems and components. It is shown that the effort is aimed at systems which can achieve significant energy cost reductions. The paper describes the potential for advanced technology to achieve commercially attractive solar thermal systems and describes some recent developments in advanced heat engines, high temperature receivers, chemical transport, and storage.

M.E.P.

**N79-33580\*** # McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.

**PHASE 1 OF THE FIRST SMALL POWER SYSTEM EXPERIMENT (ENGINEERING EXPERIMENT NO. 1). VOLUME 5: SUPPORTING ANALYSES AND TRADE STUDIES Final Report**

R. J. Holl May 1979 210 p refs Prepared for JPL 5 Vol.

(Contracts NAS7-100; JPL-955117)

(NASA-CR-162376; MDC-G7833-Vol-5) Avail: NTIS  
HC A10/MF A01 CSCL 10A

The development and design of a modular solar thermal power system for application in the 1 to 10 MWe range is described. The system is used in remote utility applications, small communities, rural areas, and for industrial uses. Thermal and stress analyses are performed on the collector subsystem, energy storage subsystem, energy transport subsystem, the power conversion subsystem, and the plant control subsystem. A.W.H.



1K Palz, Wolfgang  
1056 Solar electricity : an economic  
.P34 approach to solar energy / Wolfgang  
Palz. London ; Boston : Butterworths,  
1978.

xv, 292 p. : ill. ; 26 cm.

Physical and technological aspects of solar energy as well as cost problems are surveyed with attention to the more sophisticated conversion methods for the production of electricity. Power resources, their distribution, and their possible future patterns of use are considered, as are the physical principles of large-scale conversion of solar radiation into heat. The generation of solar electricity from thermodynamic conversion is examined with reference to flat-plate collector type generators, linear-focus type generators, and central receiver solar power plants. The description of photovoltaic conversion is concerned with different kinds of solar cells and various kinds of photovoltaic generators. The prospects of solar power for large-scale electricity production are discussed. M.L.

A GENERAL METHOD FOR THE EVALUATION OF POSSIBLE SYSTEMS FOR ELECTRIC GENERATION WITH SOLAR ENERGY, by W. G. Pollard.

IEEE Transactions on Power Apparatus and Systems, vol. PAS-97, no. 5, Sept/Oct 1978, p. 1656-1664.

The paper is organized into five distinct sections. The first consists of a brief description of possible solar-electric systems, with the two being presently developed vigorously by ERDA given prime attention, and the others only briefly indicated. The second section defines the quantities employed in the analysis characteristic of the site for a solar-electric plant and gives their measured values at ten representative sites in the United States. The third section is devoted to specifying the characteristics of the solar-electric system to be constructed and operated on a chosen site and those of any auxiliary energy-storage systems planned for operation with it. The fourth section combines the general specifications of site and system characteristics of the preceding two sections to obtain generally applicable expressions for the cost per kilowatt-hour of electricity delivered by the system. This is followed by the fifth section which describes a variety of possible applications of solar electricity and modes of operation of both very small and very large plants, and evaluates their performance.

SOLAR-POWERED MOUNTAIN CONCEPT.  
MECH. ENG., v.100, no.4, Apr.1978, p.49.

see also 877-10177

An interesting scheme for large-scale collection of solar energy utilizes the natural advantages of a mountain. A closed single-unit collector array could be placed on the south side of the mountain where it would absorb heat and transfer it to air under the array. The heated air would rise along the side of the mountain to a bin of thermal-storage rocks at the top. A heat exchanger with a working fluid could extract energy from the rock bin and drive a Rankine-cycle turbine/generator to produce energy.

A79-31416 Solar power plants. E. Bilgen and J. P. Bourquin (Lemieux, Monti, Nadon, Roy, Inc., Montreal, Canada). In: Renewable alternatives: Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg. Solar Energy Society of Canada, Inc., 1978. 16 p. 9 refs.

It is estimated that Canadian oil and natural gas resources will be virtually exhausted before the year 2000. It is expected that the energy from nuclear fission will meet, in part, the additional demand during the next fifty years. On the other hand, the first commercial fusion reactors will probably not be available before the mid-21st century. Therefore, an alternative solution to meet short and long term energy needs is essential. The solution may be the better utilization of solar energy, an unlimited energy source. Attention is given to the prospects of solar energy in Canada, aspects of solar energy conversion, thermoelectric solar energy, the optical system, the central receiver power system, solar energy and utility companies, and existing and projected solar power plants. G.R.

N80-10609# Sandia Labs., Albuquerque, N. Mex.  
SAFETY AND ENVIRONMENTAL IMPLICATIONS DOE/  
SANDIA MIDTHEMPERATURE SOLAR SYSTEMS TEST  
FACILITY

J. A. Leonard Nov 1978 7 p Presented at Environ Control  
Symp., Washington, D.C., 28 Nov 1978  
(Contract EY-76-C-04-0789)  
(SAND-78-2292C Conf-781109-8) Avail NTIS  
HC A02/MF A01

The Midthemperature Solar Systems Test Facility (MSSTF) in Albuquerque, New Mexico, is presented. The MSSTF is, at 32 kWe, the largest solar electric power plant in the U.S. and also represents the world's first application of the solar total energy concept to an actual load, an 1100 sq m office building DOE

ON-142,941 *Power sources, Solar - Thermal electric*  
1978  
FUTURE SPACE PROGRAMS. (Hearings before the  
Committee on Science and Technology, U.S. House of  
Representatives, 95th Congress, 2nd Session, Jan.  
24-26, 1978). 1978. 986p.

95th Congress, 2nd Session  
95th Congress, 2nd Session No.63  
Committee on Science and Technology

Spacecraft, Future  
Hearings - Committee on Science & Technology  
Research - Space

*Solar thermal power, p. 884 -*

AIChE Symposium Series, v.74, 1978  
no.174.

HEAT TRANSFER: RESEARCH AND APPLICATION. John C.  
Chen, ed. (Papers presented at 15th National  
Heat Transfer Conf., San Francisco, Calif.,  
Aug. 1975).

American Institute of Chemical  
Engineers  
National Conference on Heat  
Transfer

Aug.  
1975

SOLAR-THERMAL ELECTRIC POWER GENERATION USING A SYSTEM OF DISTRIBUTED  
PARABOLIC TROUGH COLLECTORS . . . J. W. Ramsey, E. M. Sparrow, and E. R. G. Eckert 271

N80-15602# Sandia Labs., Albuquerque, N. Mex.  
DEPARTMENT OF ENERGY LARGE SOLAR CENTRAL  
POWER SYSTEMS SEMI-ANNUAL REVIEW  
May 1978 262 p refs Conf. held at Reston, Va., 21-22 Mar.  
1979  
(Contract EY-76-C-04-0789)  
(SAND-79-8508) Avail: NTIS HC A12/MF A01  
Thirty papers are presented each discussing various aspects  
of the large solar central power systems program. R.E.S.

ELECTRICAL POWER FROM SUN AND WIND IN MANITOBA,  
by J. S. C. McKee  
Journal of Environmental Science and Health, Part A  
Environmental Science and Engineering, vol. A13, no. 8  
1978, p. 585-594

The potential usefulness of solar and wind energy as sources of  
electrical power is examined in the context of the projected needs  
of the province of Manitoba. It is suggested that as the capital  
costs of solar, wind and nuclear power plant construction are likely  
to become comparable within the next twenty years, a real choice  
exists for the consumer, because of purely regional factors.

TJ  
153  
.E4787  
1978  
Energy Technology Conference, 5th, Washington,  
D.C., 1978.  
Energy technology V : challenges to  
technology : proceedings of the fifth  
Energy Technology Conference, February 27-  
March 1, 1978, Washington, D.C. / edited by  
Richard F. Hill. -- Washington : Government  
Institutes, 1978.  
xiii, 1063 p. : ill.  
1. Power (Mechanics)--Congresses.

10-MEGAWATT SOLAR CENTRAL RECEIVER PILOT PLANT p. 618  
J. Lynn Rasband, Supervising Research Engineer, Southern California Edison Co.

N80-15601# Sandia Labs., Albuquerque, N. Mex.  
DEPARTMENT OF ENERGY LARGE SOLAR CENTRAL  
POWER SYSTEMS SEMI-ANNUAL REVIEW  
Nov. 1978 305 p refs Conf. held at Dallas, 19-21 Sep  
1978  
(Contract EY-76-C-04-0789)  
(SAND-78-8511) Avail: NTIS HC A14/MF A01  
Progress in the development of large solar power systems  
is reported. Hydraulic stability of solar boilers, closed cycle Brayton  
solar thermal electric power plants, heliostat development, and  
central receiver systems are discussed along with distributed  
collectors and total energy and hybrid systems. J.M.S.

# A CELLWISE METHOD FOR THE OPTIMIZATION OF LARGE CENTRAL RECEIVER SYSTEMS.

F. W. Lipps & L. L. Vant - Hull  
Solar Energy, Vol. 20, No. 6, 1978, p. 505-516.

**Abstract**—The total number of heliostats in the collector field determines the approach to the optical simulation problem. For large central receiver systems, it is desirable to introduce a cell model which establishes an array of representative heliostats (see Ref. [1] for central receiver systems). We now have an arsenal of computer programs which allows us to optimize the arrangement of heliostats in the collector field subject to the approximations of the cell model. Each cell contains an arbitrary regular two dimensional array of heliostats. For practical reasons we have limited our current study of the 100 MWe commercial model to four categories of heliostats arrangement: (1) radial cornfields, (2) radial staggers, (3) N.-S. cornfields, and (4) N.-S. staggers.

The most important results from the 100 MWe commercial model optimization study are:

- (1) Staggers are better than cornfields.
- (2) The increased cost of the tower and receiver subsystems has moved the solution to a larger cell size and a shorter tower.
- (3) No panels should be deleted from the south side of the cylindrical receiver, and
- (4) The collector field trims to a 360° configuration.

The center of the collector field is north of the tower and some compromise may be made to prevent excessive panel power asymmetry. Currently, this problem is solved by using preheat panels in the southern part of the receiver.

TJ International Symposium-Workshop on Solar  
910 Energy, Cairo, 1978.  
.173 International Symposium-Workshop on  
1978 Solar Energy : [symposium lectures], 16-  
22 June 1978, Cairo, Egypt / presented by  
Clean Energy Research Institute, University  
of Miami, Florida ; sponsored by National  
Science Foundation ; edited by T. Nejat  
Veziroglu, Homer W. Hiser. -- [s.l.:s.n.,

## SOLAR THERMAL CONVERSIONS

K. Selcuk, Jet Propulsion Laboratory, Pasadena, California,  
U.S.A.

## SOLAR ELECTRICITY PRODUCTION

A. Kettani, University of Petroleum and Minerals, Dhahran,  
Saudi Arabia

# GOAL OF CALIFORNIA SOLAR PILOT PLANT: PROVE TECHNICAL VIABILITY AND OBTAIN ACTUAL COSTS.

J. Lynn Rasband  
IEEE Transactions on Industry Applications,  
Vol. IA-14, No. 3, May/June 1978, p. 189-192.

I am pleased to introduce you to a plan—an exciting one—approved in January 1977 by the U.S. Energy Research and Development Administration (now the Department of Energy), in which California will play host to the nation's first electric generating plant connected to a utility grid and powered entirely by energy from the sun. Not only does the state have ample sunshine to power such a plant, but as the largest state in the United States with over 20 million inhabitants, we have the greatest potential need for this new technology.

**N78-32730#** Messerschmitt-Boelkow-Blohm G m b H. Otto-brunn (West Germany). Unternehmensbereich Raumfahrt.  
**DEVELOPMENT OF A PROTOTYPE 10kW SOLAR POWER PLANT Final Report**  
Dietmar Wolf, Hermann Bihlmayr, Jochen Carl, Veit Merges, Peter Prikyrl, and Peter Vinz. Bonn. Bundesmin. fuer Forsch. u. Technol. Dec 1978. 167 p. refs. In GERMAN; ENGLISH summary.  
(Contract BMFT-03E-4055-C/ETS-8000)  
(BMFT-FB-T-78-33) Avail. NTIS HC A08/MF A01; Fachinformationszentrum, Eggenstein-Leopoldshafen, West Ger DM 34.90

A solar power plant built in the Federal Republic of Germany is described. The development of three other small plants for the generation of electricity from solar energy is also reported on. The design, installation, and commissioning of the plant and of the supporting systems are reviewed. Autonomous operation using technologies as simple as possible and components from series production is emphasized. During acceptance tests the specified maximum net electrical power output of 10 kW at a cooling water temperature of 35 C, the observance of the voltage and frequency tolerances for the generated current, and partial load operation were successfully demonstrated. Further long term tests under real operation conditions are recommended.

Author (ESA)



**SOLAR THERMAL ELECTRIC POWER SYSTEMS: MANUFACTURING COST ESTIMATION AND SYSTEMS OPTIMIZATION,**  
by W. S. Duff and W. W. Shaner.  
Energy Conversion, vol. 18, no. 2, 1978, p. 81-93.

**Abstract**—Since the spring of 1973, the faculty of the School of Engineering at Colorado State University has been engaged in studies to estimate minimum cost systems for generating electric power by solar thermal means. These studies have been financed by the National Science Foundation and the Energy Research and Development Administration. The effort has consisted primarily of estimating the costs of large-volume manufacture of components of candidate systems and developing procedures whereby these complex, inter-related components are synthesized into minimum cost systems.

This paper describes the approaches used in estimating the manufacturing costs of the system components, describes the procedure developed to find systems optima, illustrates key results and presents the minimum cost designs, makes cost comparisons with present and future methods of electric power generation, and points out what can be done to help make solar electric power generation a more viable alternative.

**A78-30742** Spinning a turbine with sunlight. J. Bigger (Electric Power Research Institute, Palo Alto, Calif.). *EPRI Journal*, vol. 3, Mar. 1978, p. 14-19.

Solar-thermal energy conversion for electricity generation can be divided into two categories. One category is the intermediate-temperature range between 100 and 400 C. The second category, the high-temperature range, 500 C and above, is especially useful for electricity generation. According to the power tower design concept of solar-thermal systems, a central boiler is surrounded by tracking mirrors which reflect and focus solar energy on the receiver. A second design concept uses distributed receivers. This concept avoids the cost of a tower but adds the cost of extensive insulated piping. Attention is given to the development of solar energy programs in the U.S., the testing of first generation devices, the design of the higher-efficiency systems of the second generation, closed-cycle gas turbines, the open-cycle gas turbine, approaches for lowering the capital cost, and projects for the development of the technology.

G.R.

**TA** National SAE Symposium and Exhibition, 23rd,  
**418.9** Anaheim, Calif., 1978.

**.C6** Selective application of materials for  
**A3** products and energy / Society for the  
**1978** Advancement of Material and Process Engineering. — Azusa, Calif. : Society for the Advancement of Material and Process Engineering, c1978.

**A CERAMIC HEAT EXCHANGER FOR A BRAYTON CYCLE SOLAR ELECTRIC POWER PLANT** 366

J. D. Walton and J. N. Harris

**TJ** Pierson, Richard E., 1934—  
**810** Technician's and experimenter's  
**.P53** guide to using sun, wind, and water  
power / Richard E. Pierson. West  
Nyack, N.Y. : Parker Pub. Co., c1978.  
270 p. : ill. ; 24 cm. \$9.95

**14. Mirror-Target Systems - 227**

System Description (227) Mirror Field Sizing (228) Mirror Mounting (230) Mirror Tracking and Control (235) Target Boiler (238) Steam Engine (241) Generator (243) Battery Storage (243) Inverters (244) System Considerations (244)

**A78-46757** Vapor-turbine units with organic working fluids and prospects for their use in solar power generation / Survey by V. A. Grilikhes, M. M. Grishutin, and V. S. Evseev. (*Geliotekhnika*, no. 4, 1978, p. 3-18.) *Applied Solar Energy*, vol. 14, no. 4, 1978, p. 1-12. 43 refs. Translation.  
(For abstract see issue 24, p. 4374, Accession no. A78-52770)

The basic characteristics of cycles and energy converters for Rankine-cycle electric energy systems with organic heat-exchange fluids are surveyed. Consideration is also given to the basic design features of such systems, with emphasis on the heat exchange equipment (steam generators, regenerators, and condensers). The application of such organic systems to the production of electric power from low-potential heat sources—solar radiation, geothermal waters, and industrial waste heat—is considered. It is found that the use of organic heat-exchange fluids will lead to considerable cost savings.

B.J.

**CN-150,187** 1978  
**LIQUID METAL COOLING CONCEPTS IN SOLAR POWER APPLICATION.** P.B. Deegan, J.D. Mangus and G.A. Whitton, Westinghouse Electric Corp. (Presented at International Corrosion Forum sponsored by NACE, Houston, TX, Mar. 6-10, 1978). 1978. 15p.

**National Association of Corrosion Engineers**

**Power sources. Solar - Thermal electric.**  
**Solar collectors**  
**Cooling systems**  
**Metals. Liquid**

TK Institute of Electrical and Electronics  
7000 Engineers, Region 5,  
.125 Energy '79...cl079.  
1979 Solar-Thermal-Electric Program ~~10000~~ P16  
G. Rhodes, Department of Energy

Factors Affecting Market Initiation of Solar Total Energy  
R. Harrigan, Sandia Laboratories P24

Non-Adaptive Optics for Solar Thermal Electric Power P30  
Dr. J. D. Reichert, Crosbyton Solar Power Project, Texas  
Tech University

N79-32682# Battelle Pacific Northwest Labs., Richland, Wash.  
SYSTEMS ANALYSIS OF SOLAR THERMAL POWER  
SYSTEMS. REPORT ON TASK 1: DETERMINATION AND  
CHARACTERIZATION OF SOLAR THERMAL CONVERSION  
OPTIONS

W J Aiken, Jul 1978 65 p  
(Contract EY-76-C-06-1830)  
(PNL-2684) Avail: NTIS HC A04/MF A01

Seven general solar thermal conversion concepts were  
selected initially. The literature review confirmed that these are  
the only concepts that are developed to a level suitable for  
inclusion in the comparative analysis to be performed. A summary  
of information pertaining to these concepts is given and the  
concepts are briefly described. The seven concepts are: point-  
focusing distributed receiver system; point focusing central  
receiver system; fixed mirror/distributed focus system; line-focus  
central receiver system; line-focus distributed receiver system;  
fixed mirror line-focus distributed receiver system; and low  
concentration non-tracking systems. Author (DOE)

TK Palz, Wolfgang  
1058 Solar electricity : an economic  
.P33 approach to solar energy / Wolfgang  
Palz. London ; Boston : Butterworths,  
1978.

xv, 282 p. : ill. ; 26 cm.

Includes index. Bibliography: p.

1. Solar power plants. 2. Solar  
energy. I. Title.

831.475 77-3524 0-403709-10-3  
77V20638

N78-18615# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena  
PROCEEDINGS OF SMALL POWER SYSTEMS SOLAR  
ELECTRIC WORKSHOP. VOLUME 2: INVITED PAPERS  
R. Ferber, ed. Feb 1978 228 p Workshop held at Aspen,  
Colo., 10-12 Oct. 1977 Prepared for DOE  
(Contracts NAS7-100: EX-76-A-29-1060)  
(NASA-CR-155940, JPL-Pub-78-100, DOE/JPL-1060-78/1)  
Avail: NTIS HC A11/MF A01 CSCL 10A

The focus of this work shop was to present the commitment  
to the development of solar thermal power plants for a variety  
of applications including utility applications. Workshop activities  
included panel discussions, formal presentations, small group  
interactive discussions, question and answer periods, and informal  
gatherings. Discussion on topics include: (1) solar power  
technology options; (2) solar thermal power programs currently  
underway at the DOE, JPL, Electric Power Research Institute  
(EPRI), and Solar Energy Research Institute (SERI); (3) power  
options competing with solar; (4) institutional issues;  
(5) environmental and siting issues; (6) financial issues; (7) energy  
storage; (8) site requirements for experimental solar installations;  
and (9) utility planning. Author

### SOLAR THERMAL TEST FACILITY

Charles A. Federer, Jr.  
Sky And Telescope, Vol. 55, no. 4, April 1978  
p. 286-291

"Solar generation of electricity —  
whether through the collector farm, the  
power tower, the windmill, the photovolta-  
ic cell, or the thermal reserves of the  
sea — will be carried out on a scale large  
enough to let us decide whether or not we  
want more of it. We are going to reach  
this point, at least in the United States, in

the next ten years...."

Perhaps the most promising of the four  
techniques Behrman mentions is the com-  
bination of elevated boiler and array of  
collecting mirrors known as a power tower,  
as shown at left.

N80-14558# Sandia Labs., Livermore, Calif.  
SYSTEMS STUDIES FOR CENTRAL SOLAR THERMAL  
ELECTRIC  
Oct. 1978 492 p refs Workshop held at Houston, Tex.,  
27-30 Mar. 1978  
(Contracts EY-76-C-04-0789; AT(29-1)-789)  
(CONF-780383) Avail: NTIS HC A21/MF A01

Twenty-one articles are presented which focus on the current  
technical and economic status of central receiver solar thermal  
electric systems and future program direction. The planning and  
operational differences which the electric utilities foresee solar  
electric will encounter are discussed. Methodologies associated  
with utility network planning and operation are presented.  
National energy models are discussed along with their implications  
with respect to the future of various solar electric options. R.E.S.

TK  
2960  
.P47  
1977

ORIGINAL PAGE IS  
OF POOR QUALITY

Photovoltaic Solar Energy Conference, Luxembourg, Luxembourg, 1977.

Proceedings of the international conference held at Luxembourg, September 27-30, 1977 / Photovoltaic Solar Energy Conference. — Dordrecht, Holland ; Boston : D. Reidel Pub. Co., c1978.

1373 p. : ill. : 24 cm.

At head of title: Commission of the European Communities.

Includes bibliographical references and index.

N79-32694# Sandia Labs., Albuquerque, N. Mex. Solar Project Div.

THERMAL ENERGY STORAGE FOR ADVANCED SOLAR CENTRAL RECEIVER POWER SYSTEMS

L. G. Radosevich Aug 1978 35 p refs (Contract EY-76-C-04-0789)

(SAND-78-8221) Avail: NTIS HC A03/MF A01

Thermal energy storage is used in the advanced solar central receiver power systems currently being studied under Department of Energy sponsorship. The following are described: (1) the storage operating requirements imposed by interface constraints between energy storage and the receiver and electrical power generation systems; (2) several storage concept candidates which may meet these requirements; (3) potential cost differences between each of the storage concepts; and (4) the technical uncertainties associated with each storage concept. DOE

TJ  
R10  
.A79  
1977

Aspen Energy Forum, 4th, Aspen Institute for Humanistic Studies, 1977.

Solar architecture : proceedings of the Aspen Energy Forum 1977, May 27, 28, and 29, 1977, Aspen, Colorado / editors, Gregory E. Franta, Kenneth R. Olson ; graphics, T. Michael Manchester. — Ann Arbor, Mich. : Ann Arbor Science Publishers, c1978. ix, 331 p. : ill. : 24 cm.

BASILINE DESIGN OF COMMERCIAL CENTRAL RECEIVER SOLAR POWER PLANT

Floyd A. Blake

209

TECHNOECONOMIC ASPECTS OF CENTRAL PHOTOVOLTAIC POWER PLANTS.

Jerry O. Brady and Dennis R. Costello Solar Energy.

Vol. 19 no. 6  
p. 701-709.

1977

Abstract—The economic feasibility of central photovoltaic power plants is investigated from the perspective of an electric power utility company. The maximum acceptable price of the system is established, as a function of conventional fuel costs. Factors which would enhance the economic attractiveness of the system are analyzed. These factors include: increases in conventional fuel costs, decreases in photovoltaic system costs and subsidies to attract utility companies.

TK  
2996  
.I55  
1977

V.2

Intersociety Energy Conversion Engineering Conference, 12th, Washington, 1977.

Proceedings of the 12th Intersociety Energy Conversion Engineering Conference, Washington, D. C., August 29 through September 2, 1977. — La Grange, Ill. :

- 779194 — Design of a Sodium-Cooled, Central Receiver Solar Power Plant, W. B. Thomson, T. L. Johnson, Rockwell International, Canoga Park, Calif. .... 1203
- 779195 — Solar Thermal Conversion to Electricity Utilizing a Central Receiver, Open Cycle Gas Turbine Design, J. C. Grosskreutz, E. J. McBride, D. C. Gray, Black & Veatch, Kansas City, Mo. . 1209
- 779197 — Dynamic Modeling and Sensitivity Analysis of Solar Thermal Energy Conversion Systems, C. L. Hamilton, Jet Propulsion Lab., Pasadena, Calif. .... 1218
- 779198 — 1 MW<sub>th</sub> Solar Cavity Steam Generator Test Program, T. R. Tracey, F. A. Blake, Martin Marietta Corp., Denver, Colo.; C. Royere, CNRS, Odeillo, France; C. T. Brown, Georgia Institute of Technology, Atlanta, Ga. .... 1224



TA  
5  
.S63  
1977

Society of Engineering Science.  
Recent advances in engineering science;  
proceedings of the 14th annual meeting of  
the Society of Engineering Science, Inc. /  
edited by G. C. Sih. — Bethlehem, Pa. :  
Lehigh University, c1977.  
Held November 14-16, 1977 at Bethlehem.  
Includes bibliographical references and  
index.

1. Engineering--Congresses. I. Lehigh  
University, Bethlehem, Pa. 1297.

The potential for geothermal and solar thermal power systems  
by J. H. Anderson

# OPTIMUM CONCENTRATION RATIO FOR A SOLAR CENTRAL-RECEIVER ELECTRIC POWER PLANT

J. W. Baughn and J. B. Bergquam  
J. of Engineering Power  
Vol. 99 no. 3 July 1977  
p. 490-491

There is currently great interest in the design of solar central-receiver electric power plants [1-3].<sup>2</sup> Most of these designs use a field of mirrors to concentrate the solar radiation on a central receiver. The central receiver then is used as a heat source in a thermodynamic cycle (usually a Rankine cycle) to drive a generator. In this note a simple equation for the optimum design concentration ratio is derived. This optimum concentration ratio is found to be a function of a nondimensional receiver temperature and a nondimensional receiver number ( $N_r$ ) which is introduced in this note.

## POWER WITH HELIOSTATS

Alvin F. Hildebrandt and Lorin L. VAnt-Hull  
Science  
Vol. 197, no. 4309, September 16, 1977,  
p. 1139-1146.

A central receiver illuminated by a field of heliostats can absorb 10 to 100 megawatts of sunlight at 600° to 1000°K.

## SHADOW EFFECT IN A LARGE SCALE SOLAR POWER PLANT

O. Barra, M. Conti, E. Santamata, R.  
Scarmozzino and R. Visentin.  
Solar Energy  
Vol. 19 no. 6 1977  
p.759-762

In this work we elaborate and discuss an analytical-numerical method for the evaluation of the effect of shadowing in a typical solar power plant made of  $N$  lines of concentrating cylindrical-parabolic collectors which track the Sun by running around an E-W directed horizontal axis (Fig. 1). We neglected diffuse radiation and used insolation data referred at a latitude of 42°N (Rome, Italy).

## SOLAR THERMAL ENERGY: BRINGING THE PIECES TOGETHER. W.D. Metz.

Science, v.197, Aug.12,1977, p.650-51.

Solar thermal systems can pump water for irrigation, produce steam for industrial processes, generate electricity in small and medium-sized installations, and also supply heat for residential use. Systems that operate at temperatures between 100° and 400°C are suitable for each of these purposes, and early studies indicate that they may be most economic when they serve several purposes in a complementary fashion. Although most attention and funding in the U.S. solar program has been devoted either to low-temperature systems for solar heating and cooling or to high-temperature systems for centralized generation of electricity, a number of analysts are beginning to believe that the greatest potential for solar energy utilization by 2000 lies with intermediate-temperature systems.



# LOW-PROFILE HELIOSTAT DESIGN FOR SOLAR CENTRAL RECEIVER SYSTEMS

E. Fourakis and A. M. Severson

Solar Energy, vol. 19, no. 4, 1977, p. 349 - 356

**Abstract**—Heliostat designs intended to reduce costs and the effect of adverse wind loads on the devices were developed. Included was the low-profile heliostat consisting of a stiff frame with sectional focusing reflectors coupled together to turn as a unit. The entire frame is arranged to turn angularly about a center point. The ability of the heliostat to rotate about both the vertical and horizontal axes permits a central computer control system to continuously aim the sun's reflection onto a selected target. A schematic of the heliostat design is shown in Fig. 1. An engineering model of the basic device was built and is being tested. Control and mirror parameters, such as roughness and need for fine aiming, are being studied. The fabrication of these prototypes is in process. The model was also designed to test mirror focusing techniques, heliostat geometry, mechanical functioning, and tracking control. The model can be easily relocated to test mirror imaging on a tower from various directions. In addition to steering and aiming studies, the tests include the effects of temperature changes, wind gusting and weathering. The results of economic studies on this heliostat are also presented.

A79-34029 Complex solar-electrical plant of large capacity. A. Gokhman (Miami, University, Coral Gables, Fla.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3. (A79-34022 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1169-1187.

This paper is devoted to the serious problem of utilization of solar energy for electrical power generation. We propose an inflatable solar collector of concentrating type of parabolic shape with the ability to follow the sun. The system will have the ability to direct the concentrated beam towards the absorber by means of an auxiliary parabolic mirror which has the same focal point as the collector itself, an opening in the vertex of the collector and a flat deflecting mirror. These features permit the use of several collectors of this type for heating a common boiler in a steam turbine unit. The result is the production of electricity with units of reasonable level of capacity. Also an energy storage system is described. This system forms with the solar-electrical plant an economically feasible producer of electrical energy (Solar Complex Electrical Plant).

(Author)

## SOLAR THERMAL ELECTRICITY: POWER TOWER DOMINATES RESEARCH.

W.D. METZ.

Science, v.197, July 22, 1977. p.353-56.

At the present time, the project to develop the "power tower" is consuming 60 to 70 percent of the research money devoted to the conversion of sunlight into thermal energy and thence electricity.

A79-34027

Dual purpose solar-electric power plants. F. F. Hall (Stanford University, Stanford, Calif.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3. (A79-34022 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1135-1153.

The rationale for such plants is discussed. The elements of such plants are listed. Some elements are discussed in more detail. Dual purpose solar-electric power plants would generate both electrical power and hydrogen gas for use as a fuel. The oxygen gas liberated in the hydrogen producing electrolytic cells would also be saved and sold to owners of hydrogen age equipment. Both gases would be under 50 atma pressure or more. At these pressures the hydrogen and oxygen could be fired in compressorless gas-turbine drives of fuel cell-inverter units of high thermal efficiency. The economics of dual purpose solar-electric power plants are weighed against costs of nuclear fission reactor-electric plants including the added values of the heated steam exhausted from gas-turbines and fuel cells. A recommended energy policy for America, first published in 1975, is attached.

(Author)

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New options in energy technology / sponsored by the American Institute of Aeronautics and Astronautics, Edison Electric Institute, IEEE Power Engineering Society. -- New York : American Institute of Aeronautics and Astronautics, c1977.

149 p. : ill. ; 29 cm.

Papers nos. 77-1004-771034

Includes bibliographical references.

Integration of Solar Generation into Electric Utility Systems - J. W. BALLANCE and G. W. BRAUN.....

p. 26

Silicon Solar Photovoltaic Power Stations - C. R. CHOWANIEC, R. R. FERBER, P. F. PITTMAN, B. W. MARSHALL.....

p. 84

## SOLAR ELECTRICITY: THE HYBRID SYSTEM APPROACH M. A. Duguay

American Scientist, vol. 65, no.4, July-August 1977, p. 422 - 427

*Generation of solar electricity may first be achieved most economically in systems that combine it with other functions, such as heating and lighting*

OC Optics in adverse environments [seminar],  
371.5 August 25-26, 1977, San Diego, California /  
.067 Enrique Bernal G. [sic], Harry V. Winsor,  
1977 editors; presented by the Society of Photo-  
optical Instrumentation Engineers in con-

Predicted Performance of Heliostats for ERDA's 10 MWe Power Plant *P.48-125*  
P. Leary, J. D. Hankins, Numerical Applications Division, Sandia Laboratories

ERDA, through its Division of Solar Energy is directing and funding a competitive preliminary design proposal for a 10 MWe pilot power plant of the solar thermal central receiver type. The plant is expected to be operational in 1980 and is to be located near Barstow, CA. Sandia Laboratories in its capacity as technical manager of the project has performed technical evaluations and comparisons of the several subsystem designs supplied by the competing contractors. Predicted performance parameters for the optical subsystems are presented. These data were obtained by the application of a Monte Carlo ray trace program prepared by the authors. A short description of the program is included.

SOLAR POWER PLANTS: DARK HORSE IN THE ENERGY  
STABEL. Richard S. Caputo

Today they are far costlier than coal or nuclear power, but by the end of the century they could be competitive.

Bulletin of the Atomic Scientists, Vol. 33,  
no. 5, May 1977, p. 46-56

TC Porcny, Justin A.  
712 Survey of the emerging solar energy in-  
.001 dustry / compiled and written by Justin A.  
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1977 ed. -- San Mateo, Calif. : Solar  
Energy Information Services, c1977.  
xi, 405 p. : ill. : 24 cm.  
Bibliography: p. 360-370.

VIII. SOLAR THERMAL CONVERSION *P.447*..... 117  
IX. PHOTOVOLTAICS *P.436*..... 136

A78-22819 Development of solar tower program in the  
United States. L. L. Vant-Hull (Houston, University, Houston, Tex.).  
Optical Engineering, vol. 16, Nov.-Dec. 1977, p. 575-579. 10 refs.

The history and development of the solar tower is traced from an idea in 1969 through the first Federal funding in 1973, to a program to initiate pilot plant construction in 1977. This program involves about 3000 heliostats reflecting sunlight onto a central receiver in which 500 C steam is generated to drive a turbogenerator. This 10 MWe plant is scheduled to feed electricity into a utility grid in 1980; a 50-100 MWe demonstration plant is proposed to be on line in 1985. B.J.

TJ Greater Los Angeles Area Energy Symposium,  
163.2 1977.

.G74 Greater Los Angeles Area Energy Symposium  
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ix, 179 p. : ill. -- (Los Angeles Council  
of Engineers Scientists proceedings series ;  
v. 3)

Cover title: Q= E<sup>3</sup> : Quality of life =  
energy x economics x environment.  
Includes bibliographies.

Cost Targets for Solar Electric Plants  
S. I. Kaplan, T. D. Anderson, H. I. Bowers, J. G. Delene,  
L. C. Fuller, J. V. Wilson, Oak Ridge National Laboratory,  
Oak Ridge, Tennessee

145

A COMPARISON OF GaAs AND Si HYBRID SOLAR  
POWER SYSTEMS

J. H. Heinbockel and A. S. Roberts, Jr.

Solar Energy, vol. 19, no. 3, 1977, p. 291-  
300

# A TERRESTRIAL SOLAR THERMAL ELECTRIC POWER SYSTEM- DEVELOPMENT OF BASIC MODEL SYSTEM.

T. Tanaka, et al.

Solar Energy, v.19, 1977, p.335-341.

**Abstract**—A model system of a distributed collector power system was constructed at the Electrotechnical Laboratory, Tanashi, Tokyo, Japan in the summer of 1975. This model system consisted of a cylindrical parabolic concentrator, heat transfer loop and storage-type heat exchanger and has been used for evaluating the system performance and the dynamic characteristics of each subsystem and the whole system. This paper presents the performance of each subsystem used in the model system and summarizes results obtained from tests made on the whole system.

# ENERGY CORRADIATION USING THE REVERSIBLE AMMONIA REACTION

P. O. Carden

Solar Energy, vol. 19, no. 4, 1977, p. 365 - 378

**Abstract**—A system is described for the large scale generation of power from solar energy in which energy is transferred by means of the reversible chemical reaction  $2\text{NH}_3 \rightleftharpoons \text{N}_2 + 3\text{H}_2$ . An array of pressed steel paraboloidal mirrors is employed each having a focal absorber in which the endothermic forward reaction proceeds. The exothermic reverse reaction occurs at a common central plant and the heat energy recovered operates a thermodynamic power plant. The reactants are transferred in small diameter steel piping at ambient temperature. Storage of energy may be catered for by providing storage for the reactants. The results so far of design studies are used to assess both the technical and economic viability of the complete scheme.

TA Institute of Environmental Sciences.  
1 Environmental technology '77: proceedings.  
.I39913 -- Mt. Prospect, Ill. : The Institute, c1977.  
1977 xviii, 437 p.  
23rd annual technical meeting held in Los  
Angeles, Calif. April 25-27, 1977.  
ISBN 0-015414-17-1  
1. Environmental testing. 2.  
Environmental engineering--Societies, etc.

# PRELIMINARY ASSESSMENT OF NONTECHNICAL ISSUES RELATED TO INDUSTRIAL APPLICATION OF SOLAR-THERMAL-ENERGY SYSTEMS

By Dr. George A. Watkins, Mary Lou Brown, Benjamin Maiden, John Moore,  
Harry Smail and Seyoum Solomon . . . . .

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Solar thermal and ocean thermal : joint conference, American Section, International Solar Energy Society and Solar Energy Society of Canada, Inc., August 15-20, 1976,

# HIGH TEMPERATURE THERMAL ENERGY SYSTEMS

CENTRAL RECEIVER SOLAR THERMAL POWER PLANT SYSTEMS ANALYSIS 323

A CENTRAL RECEIVER SOLAR SYSTEM APPLICABLE TO CENTRAL POWER STATIONS 325

CENTRAL RECEIVER SOLAR THERMAL POWER 336

A BASELINE DESIGN FOR LARGE SCALE SOLAR THERMAL ELECTRIC CONVERSION 355

SOLAR FLUX DENSITY DISTRIBUTIONS ON CENTRAL POWER RECEIVERS 356

COLLECTOR FIELD DESIGN FOR A CENTRAL RECEIVER SOLAR THERMAL POWER PLANT 374

HELIOSTAT FIELD DESIGN FOR THE ERDA 5 MEGAWATT SOLAR THERMAL TEST FACILITY 385

NASA-CP-2019

N77-30279\*# Martin Marietta Corp. Denver, Colo.  
ERDA'S CENTRAL RECEIVER SOLAR THERMAL POWER SYSTEM STUDIES  
Lester J. Lippy and Thomas R. Heaton In NASA Marshall Space Flight Center Proc of the ASPE/MSFC Symp on Eng and Productivity Gains from Space Technol May 1977 p 95-123



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ASSESSMENT OF THE SOCIO-ECONOMIC AND ENVIRONMENTAL ASPECTS OF THE CENTRAL RECEIVER POWER PLANTS 91

EFFECT OF SOLAR HOME HEATING ON ELECTRIC UTILITIES 97

ECONOMIC STUDY OF SOLAR TOTAL ENERGY 113

THE USE OF OFF-PEAK ELECTRICITY FOR SOLAR HEATED HOMES 128

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Solar Central Electric Power Generation -- A Baseline Design, by Jerry C. Powell. p.125  
Potential Role of Solar Thermal Electric Power in the U.S., by D. Q. Hoover and A. D. Watt. p.130  
Solar Energy Systems for Electricity Production, by Lloyd O. Herwig. p.92

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Pittsburgh Conference on Modeling and Simulation, 7th, University of Pittsburgh, 1976. Modeling and simulation. v. 7, pt. 1 & 2. Proceedings of the seventh annual Pittsburgh Conference, held April 26-27, 1976, University of Pittsburgh / edited by William G. Vogt, Marlin H. Mickle. -- Pittsburgh : SOLAR ENERGY SYSTEMS MODELLING Session Organizer and Chairman: Eldon W. Hall, General Electric Company (over)  
SANDIA STUDIES FOR ERDA CENTRAL RECEIVER THERMAL ELECTRIC POWER PROJECT, P. J. Eicker and J. M. Brune, Sandia Laboratories p.632  
CONCEPTUAL HELIOSTAT FIELD DESIGN FOR THE ERDA 5 MEGAWATT SOLAR THERMAL TEST FACILITY AT SANDIA ALBUQUERQUE, K. L. Curtner, E. M. Fourakis and P. D. Mitchell, Honeywell Systems and Research Center p.636  
MODELING ASPECTS OF A GAS TURBINE SOLAR ELECTRIC POWER SYSTEM, E. McBride, Black and Veatch Consulting Engineers and P. D. Mitchell, Honeywell Systems and Research Center p.641  
CONCEPTUAL DESIGN OF A PARABOLIC DISH SOLAR COLLECTOR USING SIMULATION TECHNIQUES, B. P. Gupta, R. L. Buchholz, Honeywell Systems and Research Center p.646

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Photovoltaics and materials : joint conference, American Section, International Solar Energy Society and Solar Energy Society of Canada, inc., August 15-20, 1976, Winnipeg / editor, K. W. Boer. -- Cape Canaveral, Fla. : American Section of the International Solar Energy Society, c1976. x, 348 p. : ill. ; 28 cm. -- (Sharing the sun ; v. 6)  
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A COMBINED SOLAR ELECTRIC AND THERMAL SYSTEM FOR USE IN INDIVIDUAL FAMILY HOUSING 106

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Solar-Electric Residential System Tests, by D. B. Miller and K. W. Böer...  
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# SOLAR - COMMUNITIES AND TOTAL ENERGY

**N79-27682#** Atomics International, Canoga Park, Calif.  
**MANUAL FOR THE SOLAR TOTAL ENERGY SYSTEM EVALUATION PROGRAM**  
 B. L. McFarland Feb. 1979 155 p refs  
 (Contract EY-76-C-03-3210)  
 (SAND-78-7045) Avail: NTIS HC A08/MF A01

The mathematical models used by the Solar Total Energy System Evaluation Program (STESEP) are described and the way the systems were selected is discussed. The data requirements are defined, the output options and program limitations are described, and sample problems that can be used to ensure proper program operations are discussed. The code itself is described sequentially. A detailed flow diagram of the STESEP code and a glossary of the code symbols are given.

Author (DOE)

Three Solar Urban Futures: Characterization of a Future Community Under Three Energy Supply Scenarios  
 by M. Milne, M. Adelson & R. Corwin

Dept. of Energy Document DOE/EV-0052/1, October 1979

The goal of this study is to examine a hypothetical city of 100,000 people in the year 2025 based on three initially given energy supply scenarios: Future 1 specifying approximately 6 percent of the city's demand being met by solar technologies; Future 2 specifying about 25 percent; and Future 3 seeking maximum use of solar technologies. These three versions of the hypothetical city are to be identical in terms of population, goods and services produced, and energy demand.

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 1979

Intersociety Energy Conversion Engineering Conference, 14th, Boston, 1979.  
 Proceedings of the 14th Intersociety Energy Conversion Engineering Conference, Boston, Massachusetts, August 5-10, 1979.  
 -- Washington, D. C. : American Chemical Society, c1979.

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**A Distributed Microcomputer-Based Control System for a Large Scale Solar Total Energy System**, J.O. Farrell and R.S. Reska ..... 77<sup>1</sup>

799014  
**The Control System for Fort Hood Solar Total Energy System**, D.L. Black and F.C. Luffey ... 82<sup>1</sup>

799015  
**The Role of External Energy Supply in the Design Optimization of Solar Energy Districts**, R. Decher ..... 86

799995  
**The Solar Total Energy System Evaluation Program (STESEP)**, B.L. McFarland, S.J. Nalbandian and E.P. French ..... 129

**N80-10608#** Sandia Labs, Albuquerque, N. Mex.  
**DISPERSED POWER SYSTEMS AND TOTAL ENERGY**  
 V. L. Dugan Nov. 1978 3 p Presented at AIAA Conf. on Solar Energy, Phoenix, Ariz., 27 Nov. 1978  
 (Contract EY-76-C-04-0789)  
 (SAND-78-2006C Conf-781133-3) Avail NTIS  
 HC A02/MF A01

The variations of solar systems considered for dispersed applications are defined, and their relative benefits and costs are examined. Also, the role and benefits of total energy systems in dispersed applications are discussed. Although dispersed solar power systems offer large stored energy multiplication factors, they exhibit a large materials and land dependency. The importance of using most plentiful and available materials and planning a recycling materials use strategy are emphasized. DOE

## ENERGY FACILITIES GOING UNDERGROUND

KEY WORDS: Energy; Energy conservation; Environmental effects; Environmental factors; Pumped storage; Radioactive wastes; Site selection; Underground facilities; Underground storage; Underground water storage; Waste disposal

ABSTRACT: Environmental pressures, combined with continuing development of hard-rock excavation techniques, have turned attention to the placement of major engineering facilities underground. Primary areas of interest include underground oil storage in unlined rock caverns excavated in salt or in crystalline rock. Recent studies in California and in Ontario have, however, indicated the cost of undergrounding nuclear power plants will exceed the net cost of surface plants by 27% to 34%. Several studies of underground energy storage, either in the form of compressed air or as pumped hydro, are currently being funded by the U.S. Department of Energy and tentative site selections for demonstration facilities have been made.

REFERENCE: Willett, David C., "Energy Facilities Going Underground," CIVIL ENGINEERING—ASCE, December, 1978, pp. 54-57

NSC-15600# Sandia Labs., Albuquerque, N. Mex. Solar Technical Liaison Div.  
DYNAMIC STORAGE IN SOLAR TOTAL ENERGY PROGRAMS

R. P. Stromberg 1978 27 p. refs. Presented at the Seminar on Solar Energy Storage, Trieste, Italy, 4 Sep 1978 (Contract EY-76-C-04-0789)  
(SAND-78-0958C. CONF-780944-1) Avail: NTIS HC A03/MF A01

A program of research and development to establish the feasibility of the Solar Total Energy Concept is described. The major items of actual hardware are a 32 kW Midtemperature Solar Systems Test Facility at Albuquerque, NM and two planned Large Scale Experiments at Shenandoah, GA and Ft Hood, TX. These programs are described with reference to current literature. DOE

## ECONOMIC ANALYSIS OF SOLAR TOTAL ENERGY SYSTEMS

Jesse C. Denton

Energy Conversion, vol. 16, no. 4, 1977, p. 199 - 204

Abstract—An economic analysis of a solar total energy system is provided on basic investment analysis principles. Assumptions and simplifications of procedure are stated. Assuming that the technology becomes technologically mature in 1990, the first system built (of the type analysed) is anticipated to have a net present value just over \$53 million based on a 25 yr economic lifetime and forecasted values for inflation rate, energy escalation rate, cost of capital, cost of operations, cost of maintenance, depreciation, construction time, costs of gas and electricity, and capital cost. A specific case is analysed. Error and sensitivity analyses are not included.

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## Intersociety Energy Conversion Engineering Conference, 12th, Washington, 1977. Proceedings ...c1977

- 779201 — Deterministic Insolation Estimates for Solar Total Energy Systems, E. P. French, Rockwell International, Canoga Park, Calif. .... 1231  
779204 — Miniature Solar Electric Power System, J. E. Drummond, Maxwell Lab., Inc., San Diego, Calif. .... 1238  
779205 — Experimental Evaluation of a Solar/Wind Powered Space Heating and Hot Water Heating System in the Pacific Northwest, A. Yamagiwa, Seattle City Light, Seattle, Wash. .... 1243  
Commercial Applications of Solar Total Energy Systems — M. G. Boobar, B. L. McFarland, S. J. Nalbandian, and K. E. Smith, Atomic International Division, Rockwell International, Canoga Park, California ..... 1693

## SOLAR ENERGY AND THE RESIDENCE SOME SYSTEMS ASPECTS

Richard C. Neville

Solar Energy

Vol. 19, no. 5, 1977

p. 539-548

Abstract—The feasibility, in an energy flow sense, of providing heating, cooling and electrical power for individual homes using some form of solar energy converter on the roof of each residence is considered. A model for home power requirements and solar insolation which reflects residence construction, local weather and geographic location is developed. This is used to demonstrate that 50-90 per cent of the homes in the U.S.A. could be self-powered from solar energy providing sufficient insulation is used and adequate energy conversion techniques are developed.

## SELF-SUPPORTING ACTIVE SOLAR ENERGY SYSTEM.

R. Zakhariya.

ASHRAE J., Nov. 1977, p. 60-

Introducing a new type of solar collector and a new type of solar energy total system for which patents have been applied for by the author.



## SOLAR - SATELLITE SOLAR POWER STATIONS

Energy, v.4, no.5 /

Oct.  
1979

**RENEWABLE ENERGY PROSPECTS. (Special issue).  
(Proceedings of a Conference on Non-Fossil Fuel  
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Sponsored by the United Nations University at  
Tokyo, Japan). Wilfrid Bach, et al, eds.**

Moses, H.: Impacts of satellite power system technology ..... 799

**Abstract** In the Satellite Power System (SPS) considered here, energy from the sun is collected by an array, 5 km x 10.5 km in area, located in geostationary orbit. The array contains either silicon or gallium aluminum arsenide photovoltaic cells whose output is transformed to 2.45 GHz microwaves. These are beamed to earth to a 10 km x 15 km rectifying antenna (rectenna) which rectifies the microwaves and interfaces the power with utility power lines. Each unit will produce 5 million kW of electrical power (5 GWe). Sixty such units are planned at the rate of two per year over 30 yr.

This paper deals with an assessment of both the environmental and societal aspects of an SPS. Under environmental aspects, attention is devoted to the health and ecological effects of both microwave radiation and other effects. The interaction of microwaves with the atmosphere is examined particularly as it affects communication. Nonelectromagnetic radiation effects such as noise and increased pollution are also considered.

Societal aspects are divided into four general categories: (1) resources, which includes materials required, availability of suitable land, and energy used to construct an SPS; (2) institutional, which deals with State and other regulations, financial management, and utility integration; (3) international aspects including organizational structures, and (4) societal aspects including factors dealing with social acceptance and the need for communications with the younger people.

**Satellite Power Systems (SPS). Concept Development  
and Evaluation Program: Preliminary Assessment**

Dept. of Energy Document DOE/ER 0041, September 1979

### **SOLAR POWER SATELLITES.**

Astronautics & Aeronautics, vol. 17, no. 1, January 1979, p.14-17.

The solar power satellite (SPS) concept proposed by P. E. Glaser in 1968 is one of the few solar options which offers baseload capability. Although it appears to be technically feasible, a considerable effort will be needed to determine its economic, environmental, societal, and political viability.

The AIAA has studied the SPS concept and its implications in considerable detail, and offers in this paper the Institute's collective professional position on the subject, including specific recommendations for pertinent research and technology efforts.

**N79-23484\*** Rockwell International Corp., Downey, Calif.  
Satellite Systems Div.

**SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION  
STUDY, EXHIBIT C. VOLUME 1: EXECUTIVE SUMMARY  
Final Report**

G. M. Hanley Mar. 1979 66 p refs 7 Vol.  
(Contract NAS8-32475)

(NASA-CR-161218; SSD 79-0010-1-Vol-1) Avail: NTIS  
HC A04/MF A01 CSCL 10B

The Department of Energy (DOE) is currently conducting an evaluation of approaches to provide energy to meet demands in the post-2000 time period. The Satellite Power System (SPS) is a candidate for producing significant quantities of base-load power using solar energy as the source. The SPS concept is illustrated for a solar photovoltaic concept. A satellite, located at geosynchronous orbit, converts solar energy to dc electrical energy using large solar arrays. This study is a continuing effort to provide system definition data to aid in the evaluation of the SPS concept.

G. Y.

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AIAA/NASA Conference on Advanced Technology  
for Future Space Systems, Hamp VA.  
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A collection of technical papers / sponsored  
by American Institute of Aeronautics and  
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Administration. -- (New York : American  
Institute of Aeronautics and Astronautics,  
1979)

An Economic Analysis of a Commercial Approach to the Design and Fabrication  
of a Space Power System - Z. PUTNEY and J. BEEN ----- p. 300 79-0914

ABO-18800 Cost effectiveness requirements for space  
power stations. G. K. C. Pardoe (General Technology Systems, Ltd.,  
Brentford, Middx., England). *Acta Astronautica*, vol. 6, Dec. 1979,  
p. 1745-1752.

The concept of converting solar energy in orbital space stations  
and transmitting electrical power to Earth at radio frequency, is  
receiving increasing attention both in paper studies and experimental  
and development work. The projects conceived are large in scale and  
implications and will demand major resources in their development  
and deployment. This paper, therefore, examines the requirements  
which together will determine the appropriate levels of cost  
effectiveness of space power stations and should assist in establishing  
critical or sensitive areas which will influence the operational validity  
of the concepts. The r.f. transmission of electric power to and from,  
or between, spacecraft may itself have wider implications and is  
another aspect considered in the paper. In summary, the paper does  
not seek to introduce new design concepts, but appraises the  
situation and exposes indicators concerning cost effectiveness.

(Author)

Solar Power Satellite ground stations.  
by R. Andryczk, P. Foldes, J. Ghestek & B.M. Kaupang

IEEE Spectrum, Vol. 16, No. 7, July 1979, p. 51-55

The ground systems for microwave beaming from the  
SPS would require a rectifying antenna with over 13  
billion elements.

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AAS Anniversary Conference, 25th, Houston,  
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The future United States space program  
...c1979 (Card 2)  
ISBN 0-87703-098-7 (pt.1) 0-87703-  
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Richard S. II. Naumann, Albert. III.

Casting the Satellite Power System (AAS 78-166)  
George A. Hazelrigg, Jr. p. 619  
Series.

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ABO-17132 Impacts of satellite power system technology.  
H. Moses (U.S. Department of Energy, Office of Health and  
Environmental Research, Washington, D.C.). (*United Nations University,  
East-West Center, International Institute for Applied Systems  
Analysis, and University of Hawaii, Conference on Non-Fossil Fuel  
and Non-Nuclear Fuel Energy Strategies, Honolulu, Hawaii, Jan.  
9-12, 1979*) *Energy* (UK), vol. 4, Oct. 1979, p. 799-809. 15 refs.

In the Satellite Power System (SPS) considered, energy from the  
sun is collected by an array 5 km x 10.5 km in area, located in  
geostationary orbit. The array contains either silicon or gallium  
aluminum arsenide photovoltaic cells whose output is transformed to  
2.45 GHz microwaves. These are beamed to earth to a 10 km x 16  
km rectifying antenna (rectenna) which rectifies the microwaves and  
interfaces the power with utility power lines. Each unit will produce  
5 million kW of electrical power (5GWe). Sixty such units are  
planned at the rate of two per year over 30 yr. The paper deals with  
an assessment of both the environmental and societal aspects of an  
SPS. Under environmental aspects, attention is devoted to the health  
and ecological effects of both microwave radiation and other effects.  
The interaction of microwaves with the atmosphere is examined  
particularly as it affects communication. Nonelectromagnetic  
radiation effects such as noise and increased pollution are also  
considered.

(Author)

Proceedings of the Workshop on Stratospheric and  
Mesospheric Impacts of Satellite Power Systems (SPS).

Dept of Energy Report CONF-7809197, December 1979  
Conference held September 6-8, 1978

NASA CP-2071 *summary report* 1979

SPACECRAFT CHARGING TECHNOLOGY - 1978. (Conf. sponsored by AFGL and LeRC. Held U.S. Air Force Academy, Colorado Springs, Colo., Oct.31-Nov.2, 1978). 1978. 899p.

PLASMA SHEATH EFFECTS AND VOLTAGE DISTRIBUTIONS OF LARGE HIGH-POWER SATELLITE SOLAR ARRAYS

Lee W. Parker . . . . . *P.341*

MAGNETIC SHIELDING OF LARGE HIGH-POWER-SATELLITE SOLAR ARRAYS USING INTERNAL CURRENTS

Lee W. Parker and William A. Oran . . . . . *P.376*

SPACE ENVIRONMENTAL EFFECTS AND THE SOLAR POWER SATELLITE

John W. Freeman, David Cooke, and Patricia Reiff *P.408*

FIRST STEPS TO THE SOLAR POWER SATELLITE.

IEEE Spectrum, vol 16, no 5, May 1979, p. 52-58.

Guidelines issued by the Department of Energy and NASA provide a reference point for an ambitious program.

Satellite Power Systems (SPS). Concept Development and Evaluation Program. Preliminary Assessment

Dept. of Energy Report DOE/ER 0041, September 1979

The Satellite Power System (SPS) is an emerging concept for capturing solar energy in space for use in producing electrical energy on earth. To develop an understanding of the technical and economic feasibility and of the environmental and societal acceptability of the SPS is an enormous challenge. The Department of Energy and the National Aeronautics and Space Administration are engaged in a three-year assessment of the SPS that began in the fall of 1977 and will be completed in the summer of 1980.

The DOE/NASA assessment is engaging the efforts of many organizations in the United States and is developing a large body of information. At approximately the mid-point of the assessment, this preliminary project assessment report describes what has been done and what has been learned with an emphasis on the overriding issues. The document is a preliminary report.

TL  
787

.A2  
v. 38  
*pt. 1*

AAS Anniversary Conference, 25th, Houston, 1978.

The future United States space program : proceedings of the 25th AAS Anniversary Conference held October 30 - November 2, 1978, Houston, Texas / edited by Richard S. Jonston, Albert Naumann, Jr., Clay W. C. Fulcher. -- San Diego : Univett, c1979.

2 v. : ill. -- (Advances in the astronomical sciences : v. 38)

An Evolutionary Solar Power Satellite Program (AAS 78-153)  
G. M. Hanley, W. R. Rhothe *P.217*

THE SOLAR POWER SATELLITE CONCEPT.  
Peter E. Glaser.

AIAA Student Journal, vol 17, no 2, Summer 1979.  
p. 32-41.

*Solar energy is available twenty-four hours a day in space. What was once a "way out" scheme to tap this resource, the concept of beaming power to Earth from large scale satellites in space, has become economically and technically feasible.*



TL AAS Anniversary Conference, 25th, Houston,  
787 1978.  
.A2 The future United States space program  
v. 38 ...c1979 (Card 2)  
pt. 2 ISBN 0-87703-098-7 (pt.1) 0-87703-  
099-5 (pt.2)  
1. Space flight--United States--Planning.  
2. Astronautics--Congresses. I. Johnston,  
Richard S. II. Naumann, Albert. III.

Solar Power Space Stations: Some Issues of Law and Policy  
(AAS 78-199) p. 595  
Stephen Gorove

629.445 p. 595

N79-23489\*# Rockwell International Corp., Downey, Calif.  
Satellite Systems Div.

**SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION  
STUDY, EXHIBIT C. VOLUME 7: SYSTEM/SUBSYSTEM  
REQUIREMENTS DATA BOOK Final Report**  
G. M. Hanley Mar. 1979 118 p. refs 7 Vol.  
(Contract NAS8-32475)

(NASA-CR-161223; SSD-79-0010-7-Vol-7) Avail: NTIS  
HC A06/MF A01 CSCL 10B

Volume 7 of the Satellite Power Systems (SPS) Concept  
Definition Study final report summarizes the basic requirements  
used as a guide to systems analysis and is a basis for the  
selection of candidate SPS point design(s). Initially, these collected  
data reflected the level of definition resulting from the evaluation  
of a broad spectrum of SPS concepts. As the various concepts  
matured these requirements were updated to reflect the  
requirements identified for the projected satellite system/  
subsystem point design(s). The identified subsystem/systems  
requirements are defined, and where appropriate, recommenda-  
tions for alternate approaches which may represent improved  
design features are presented. A more detailed discussion of  
the selected point design(s) will be found in Volume 2 of this  
report. G.Y.

GREATER EFFORT ON SOLAR POWER URGED, by Graig Covault.  
Aviation Week & Space Technology, vol. 110, no. 9,  
February 1979, p. 51.

Washington--Limited budget outlook for the most basic studies on solar power satellite  
concepts dictates that the aerospace industry must show exceptional management  
leadership to insure such techniques are given a thorough appraisal, according to  
Christopher C. Kraft, Jr., Johnson Space Center director.

TL AAS Anniversary Conference, 25th, Houston,  
787 1978.  
.A2 The future United States space program  
v. 38 ...c1979 (Card 2)  
pt. 2 ISBN 0-87703-098-7 (pt.1) 0-87703-  
099-5 (pt.2)  
1. Space flight--United States--Planning.

Financial/Management Scenarios for a Satellite Power System  
Program (AAS 78-144)

J. Peter Vajk, Richard D. Stutzke, Robert Salkeld,  
G. Harry Stine, Mark S. Klan p. 479

ENERGY ANALYSIS OF THE SOLAR POWER SATELLITE. R. A.  
HERENDEEN, T. KARY, and J. REBITZER.

Science. v. 205, no. 4405, August 3, 1979, p. 451-454.

Summary. The energy requirements to build and operate the proposed Solar Power  
Satellite are evaluated and compared with the energy it produces. Because the tech-  
nology is so speculative, uncertainty is explicitly accounted for. For a proposed 10-  
gigawatt satellite system, the energy ratio, defined as the electrical energy produced  
divided by the primary nonrenewable energy required over the lifetime of the system,  
is of order 2, where a ratio of 1 indicates the energy breakeven point. This is signifi-  
cantly below the energy ratio of today's electricity technologies such as light-water  
nuclear or coal-fired electric plants.

N79-23496\*# PRC Energy Analysis Co., McLean, Va.  
**POTENTIAL OF LASER FOR SPS POWER TRANSMISSION**  
Claud N. Bain Oct. 1978 111 p. refs Sponsored by NASA  
and DOE

(Contract EG-77-C-01-4024)

(NASA-CR-157432; HCP/R-4024-07)  
HC A06/MF A01 CSCL 10B

Avail: NTIS

Research on the feasibility of using a laser subsystem as  
an additional option for the transmission of the satellite power  
system (STS) power is presented. Current laser work and  
predictions for future laser performance provide a level of  
confidence that the development of a laser power transmission  
system is technologically feasible in the time frame required to  
develop the SBS. There are significant economic advantages in  
lower ground distribution costs and a reduction of more than  
two orders of magnitude in real estate requirements for ground  
based receiving/conversion sites. M.M.M.

SOME PERSPECTIVES ON RESEARCH INTO THE BIOLOGICAL  
RESPONSE TO NON-IONIZING ELECTROMAGNETIC RADIATION,  
by Joseph C. Sharp.  
Radio Science, vol. 14, no. 1, Jan./Feb. 1979, p.5-10.

Research on biological effects of RF radiation has undergone a turbulent series of swings in the United States during the last three decades. A peak of activity during the Tri-Service era of the late 1950s and early 1960s was followed by a nadir—in 1965, not a single federal agency was supporting research in the area. The resurgence of research during the past decade—13 federal agencies or departments are now annually supporting a multi-million dollar effort—is examined in the light of two related projects involving NASA: the proposed Space Power Station (SPS) and the Search for Extraterrestrial Intelligence (SETI). Interwoven in the complex of technological, economic, and political considerations that affect both projects is the eventuation of a new pragmatism—a moral retrenchment—that the author sees as a potential decline in the national spirit of outreach and enterprise. In the entirely justifiable search for bread and energy, the US may also be pursuing a course that starves and chills its national soul.

N79-23492\*# Kotin (Allan D.) Economic Consultants, Los Angeles, Calif.  
**SATELLITE POWER SYSTEM (SPS) RESOURCE REQUIREMENTS (CRITICAL MATERIALS, ENERGY AND LAND)**  
Allan D. Kotin Oct. 1978 126 p refs Sponsored by NASA and DOE Prepared for PRC Energy Analysis Co.  
(Contract EG-77-C-01-4024)  
(NASA-CR-158680, HCP/R-4024-02) Avail: NTIS HC A07/MF A01 CSCL 10B

The resource impacts of the proposed satellite power system are evaluated. Three classes of resource impacts are considered separately: critical materials, energy, and land use. The analysis focuses on the requirements associated with the annual development of two five-gigawatt satellites and the associated receiving facilities. M M M

Utility Interface Requirements for a Solar Power System  
by P.J. Donalek & J.L. Whysong

Dept. of Energy Document DOE/ER-0032, September 1978  
Contract no. 31-109-38-4112

For this study it was specified that the southern tier of the United States (South of the 36th parallel) should be examined to see what problems might develop with the installation of a Satellite Power System in the year 2000.

N79-23498\*# Rockwell International Corp., Downey, Calif.  
Satellite Systems Div.  
**SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY, EXHIBIT C. VOLUME 2, PART 2: SYSTEM ENGINEERING, COST AND PROGRAMMATIC**  
Final Report  
G. M. Hanley Mar. 1979 113 p refs 7 Vol.  
(Contract NAS8-32475)  
(NASA-CR-161220, SSD-79-0010-2-2-Vol-2-Part-2) Avail: NTIS HC A08/MF A01 CSCL 10B

Volume 2, Part 2, of a seven volume Satellite Power Systems (SPS) report is presented. Part 2 covers cost and programmatic and is divided into four sections. The first section gives illustrations of the SPS reference satellite and rectenna concept, and an overall scenario for SPS space transportation involvement. The second section presents SPS program plans for the implementation of PHASE C/D activities. These plans describe SPS program schedules and networks, critical items of systems evolution/

technology development, and the natural resources analysis. The fourth section presents summary comments on the methods and rationale followed in arriving at the results documented. Suggestions are also provided in those areas where further analysis or evaluation will enhance SPS cost and programmatic definitions.

SOLAR POWER SATELLITE: PUTTING IT TOGETHER

IEEE Spectrum, vol. 16, no. 9, September 1979, p. 37-40.

Enormous structures involving unique fabrication methods call for new materials, tools, and heavy-lift vehicles.

A79-44277 # The solar power satellite concept. P. E. Glaser (Arthur D. Little, Inc., Cambridge, Mass.). *AIAA Student Journal*, vol. 17, Summer 1979, p. 32-41, 25 refs.

A method to utilize solar energy through solar power satellites (SPS) is presented. The electricity produced by solar energy conversion will be fed to microwave generators forming part of a planar, phased-array transmitting antenna, which in turn is designed to direct a microwave beam to one or more receiving antennas. Variations in solar power output due to eclipses, equinox periods and other predictable interruptions, are expected to range from 1.309 kW/sq m to 1.399 kW/sq m. Technological options for solar energy conversion, including photovoltaic and thermal-electric processes are described. Attention is also given to the assembly and maintenance of SPS, economic and environmental implications, as well as microwave biological effects and other impacts, which include thermal pollution, land despoilment and resource consumption.

C.F.W.

CN-150,571 1979  
**SOLAR POWER SATELLITE.** (Hearings before the  
 Subcommittee on Space Science and Applications  
 of the Committee on Science and Technology,  
 U.S. House of Representatives, 96th Congress,  
 1st Session, Mar.28-30,1979). 1979. 342p.

96th Congress, 1st Session  
 96th Congress, 1st Session No.15  
 Committee on Science and Technology

**Hearings - Committee on Science & Technology**  
**Satellite solar power stations**

A79-44160 Energy analysis of the Solar Power Satellite.  
 R. A. Herendeen, T. Kary, and J. Rebitzer (Illinois, University,  
 Urbana, Ill.). *Science*, vol. 205, Aug. 3, 1979, p. 451-454. 25 refs.

The energy requirements to build and operate the proposed  
 Solar Power Satellite are evaluated and compared with the energy it  
 produces. Because the technology is so speculative, uncertainty is  
 explicitly accounted for. For a proposed 10-gigawatt satellite system,  
 the energy ratio, defined as the electrical energy produced divided by  
 the primary nonrenewable energy required over the lifetime of the  
 system, is of order 2, where a ratio of 1 indicates the energy  
 breakeven point. This is significantly below the energy ratio of  
 today's electricity technologies such as light water nuclear or  
 coal-fired electric plants. (Author)

TL AAS Anniversary Conference, 25th, Houston,  
 787 1978.  
 .A2 The future United States space program  
 v.38 ...c1979 (Card 2)  
 271 ISBN 0-87703-098-7 (pt.1) 0-87703-  
 099-5 (pt.2)  
 1. Space flight--United States--Planning.  
 2. Astronautics--Congresses. I. Johnston,  
 Richard S. II. Naumann, Albert. III.

A Development Strategy for the Solar Power Satellite (AAS 78-154) 235  
 Daniel L. Gregory p, 235

TL AAS Anniversary Conference, 25th, Houston,  
 787 1978.

.A2 The future United States space program  
 v.38 ...c1979 (Card 2)  
 pt.2 ISBN 0-87703-098-7 (pt.1) 0-87703-  
 099-5 (pt.2)

1. Space flight--United States--Planning.  
 2. Astronautics--Congresses. I. Johnston,  
 Richard S. II. Naumann, Albert. III.

Health Maintenance and Health Surveillance Considerations for  
 an SPS Space Construction Base Community (AAS 78-176)  
 James P. Kornberg, Philip K. Chapman, Peter E. Glaser  
 p 651

022.443

**SOLAR POWER SATELLITES: THE LASER OPTION**, by Wayne S.  
 Jones and Maxwell W. Hunter II.  
 Astronautics & Aeronautics, vol. 17, no. 3, March 1979,  
 p.59- con't on 67.

The many favorable characteristics of laser power transmitted from Sun driven satellites to ground  
 stations recommend that this alternative to a microwave Solar Power Satellite (SPS) be pursued through  
 more substantial R&D.

N80-10600\* RCA Labs., Princeton, N. J. David Sarnoff  
 Research Center

**ANALYSIS OF S-BAND SOLID-STATE TRANSMITTERS FOR  
 THE SOLAR POWER SATELLITE** Final Report. 1 Nov.  
 1978 - 1 Jun. 1979

E. F. Belohoubek, M. Ettenberg, H. C. Huang, M. Nowogrodzki,  
 and F. N. Sechi 1 Jun. 1979 79 p refs

(Contract NAS9-15755)  
 (NASA-CR-160320) Avail: NTIS HC A05/MF A01 CSCL  
 10A

The possibility of replacing the Reference System antenna  
 in which thermionic devices are used for the dc-to-microwave  
 conversion, with solid-state elements was explored. System,  
 device, and antenna module tradeoff investigations strongly point  
 toward the desirability of changing the transmitter concept to a  
 distributed array of relatively low power elements, deriving their  
 dc power directly from the solar cell array and whose microwave  
 power outputs are combined in space. The approach eliminates  
 the thermal, weight, and dc-voltage distribution problems of a  
 system in which high power tubes are simply replaced with  
 clusters of solid state amplifiers. The proposed approach retains  
 the important advantages of a solid state system: greatly enhanced  
 reliability and graceful degradation of the system. ARH



**N79-27707#** Technische Universitaet, Munich (West Germany). Lehrstuhl fuer Raumfahrttechnik.

**POWERSAT: AN EVALUATION**

Harry O. Ruppe May 1977 93 p refs

(TUM-LRT-TB-22/2) Avail: NTIS HC A05/MF A01

The Powersat concept of geostationary satellite energy generation and microwave transmission to earth was evaluated. A net power output of 10 GW per station and a space system life time 30 years were assumed. Two versions, one with rotating machinery, the other with solar cells, were considered. Three transportation methods were studied. Some other alternatives are also briefly reviewed. The rotating machinery system is preferred, as compared with solar cell systems current technology because of advantages in total weight, cost, and radiation immunity. Transport with a two stage chemical carrier to a 700 km orbit and then with electric self-propulsion is also preferred. It is concluded that energy spent will be recovered in from one to four years of operation. Other economic advantages are discussed.

Author (ESA)

**N79-23493#** Environmental Resources Group, Los Angeles, Calif.

**SATELLITE POWER SYSTEM (SPS) PUBLIC ACCEPTANCE**

Arrie Bachrach Oct. 1978 85 p refs Sponsored by NASA and DOE Prepared for PRC Energy Analysis Co.

(Contract EG-77-C-01-4024)

((NASA-CR-157429; HCP/R-4024-04)

Avail: NTIS

HC A05/MF A01 CSCL 10B

An outlook on the public acceptability of the solar satellite power system (STS) program is presented and means of monitoring it is described. A discussion of various recent trends that made public acceptance of large scale programs more important are discussed as well as some elements of the public acceptance process. International nongovernmental public acceptance is reported. A discussion is presented of techniques that are available to help clarify and achieve consensus among the conflicting impact perceptions, priorities, and values of interests of those who may be affected by SPS.

M.M.M.

A80-20643

The satellite power system concept and program. G. M. Hanley (Rockwell International Corp., El Segundo, Calif.). *Society of Allied Weight Engineers, Annual Conference, 38th, New York, N.Y., May 7-9, 1979, Paper 1305*. 14 p.

The paper summarizes the approaches that have been considered for the satellite power system (SPS) and the current reference concept defined by NASA and the Department of Energy (DOE). The overall system's characteristics are described. The NASA-DOE reference SPS system consists of two different satellite approaches, both of which utilize solar photovoltaic energy conversion and have 5 GW power outputs on the ground. One approach uses a silicon solar cell array without reflecting concentrators, while the other employs gallium arsenide solar cells in an array with flat concentrators. The approach to satellite construction and transportation system characteristics are also described.

V.T.

**N79-23488#** Rockwell International Corp., Downey, Calif. Satellite Systems Div.

**SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION**

**STUDY, EXHIBIT C. VOLUME 4: TRANSPORTATION**

**ANALYSIS Final Report**

G. M. Hanley Mar. 1979 268 p refs 7 Vol

(Contract NAS8-32475)

(NASA-CR-161222; SSD-79-0010-4-Vol-4) Avail: NTIS

HC A12/MF A01 CSCL 10B

Volume 4 of a seven volume Satellite Power Systems (SPS) is presented. This volume is divided into the following sections: (1) transportation systems elements; (2) transportation systems requirements; (3) heavy lift launch vehicles (HLLV); (4) LEO-GEO transportation; (5) on-orbit mobility systems; (6) personnel transfer systems; and (7) cost and programmatic. Three appendixes are also provided and they include: horizontal takeoff (single stage to orbit technical summary); HLLV reference vehicle trajectory and trade study data; and electric orbital transfer vehicle sizing.

G.Y.

**N79-23487#** Rockwell International Corp., Downey, Calif. Satellite Systems Div.

**SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION**

**STUDY, EXHIBIT C. VOLUME 2, PART 2: SYSTEM**

**ENGINEERING, COST AND PROGRAMMATICS, AP-**

**PENDIXES Final Report**

G. M. Hanley Mar. 1979 318 p refs 7 Vol.

(Contract NAS8-32475)

(NASA-CR-161221; SSD-79-0010-2-2-Vol-2-Pt-2-APP) Avail:

NTIS HC A14/MF A01 CSCL 10B

Appendixes for Volume 2 (Part 2) of a seven volume Satellite (SPS) report are presented. The document contains two appendixes. The first is a SPS work breakdown structure dictionary. The second gives SPS cost estimating relationships and contains the cost analyses and a description of cost elements that comprise the SPS program.

G.Y.

**N79-23485#** Rockwell International Corp., Downey, Calif. Satellite Systems Div.

**SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION**

**STUDY, EXHIBIT C. VOLUME 2, PART 1: SYSTEM**

**ENGINEERING Final Report**

G. M. Hanley Mar. 1979 257 p refs 7 Vol.

(Contract NAS8-32475)

(NASA-CR-161219; SSD-79-0010-2-1-Vol-2-Pt-1) Avail: NTIS

HC A12/MF A01 CSCL 10B

Volume 2, Part 1, of a seven volume report is presented. Part 1 encompasses Satellite Power Systems (SPS) systems engineering aspects and is divided into three sections. The first section presents descriptions of the various candidate concepts considered and conclusions and recommendations for a preferred concept. The second section presents a summary of results of the various trade studies and analysis conducted during the course of the study. The third section describes the Photovoltaic Satellite Based Satellite Power System (SPS) Point Design as it was defined through studies performed during the period January 1977 through March 1979.

G.Y.

**N80-10657#** PRC Energy Analysis Co., Los Angeles, Calif. **SATELLITE POWER SYSTEM (SPS) PRELIMINARY SOCI-**

**ETAL ASSESSMENT**

Charles Bloomquist, A. Daurio, and S. Shotland May 1979

69 p refs

(Contract EG-77-C-01-4024)

(HCP/R4024-01/14) Avail: NTIS HC A04/MF A01

The findings of fourteen papers dealing with SPS societal issues are presented. While numerous societal problems and potential concerns are delineated, no program stoppers were identified. Thus, in so far as the societal ramifications of an SPS are concerned, additional study of the concept is warranted. Societal topics which merit particular attention in the future are delineated. These include rectenna site availability, utility integration, and institutional/international considerations. Study findings that might be used in a comparative assessment of the SPS with alternative energy systems are presented. Methodological considerations for future SPS societal research are also discussed.

DOE

**N80-19618#** Boeing Aerospace Co., Seattle, Wash. **SOLAR POWER SATELLITE SYSTEM DEFINITION STUDY, VOLUME 3: OPERATIONS AND SYSTEMS SYNTHESIS, PHASE 2 Final Report, Jan. - Nov. 1979**

Nov. 1979 596 p refs 5 Vol.

(Contract NAS9-15636)

(NASA-CR-160480; D180-25461-3)

Avail: NTIS

HC A25/MF A01 CSCL 10A

The results of the operations analyses are reported. Some of these analyses examined operations aspects of space vehicle in-space maintenance. Many of the analyses explored in great depth operations concerned the LEO Base cargo handling operations. Personnel transportation operations and cargo packaging were also analyzed. These operations analyses were performed to define the operational requirements for all of the SPS system elements so that equipment and facilities could be synthesized, and to make estimates of the manpower requirements. An overall, integrated, end-to-end description of the SPS operations is presented. The detailed operations analyses, upon which this integrated description was based, are included. F.O.S.

A79-48026

Energy for the year 2000 - The SPS concept (Energie für das Jahr 2000 - Das SPS-Konzept). G. Tschulena, *Nachrichten Elektronik*, vol. 33, Aug. 1979, p. 249-254. 7 refs. In German.

The solar power satellite (SPS) system is examined. Different aspects of the project are discussed including the energy conversion technology such as solar cells of different compounds and thermoelectric converters. Also covered are the microwave transmission system, and environmental concerns such as biological effects and the dispersion of microwaves. Consideration is also given to realization of the project through the Space Shuttle. Finally, the development program of the SPS project is discussed.

M.E.P.



## SOLAR POWER SATELLITES: MICROWAVES DELIVER THE POWER.

IEEE Spectrum, vol 16, no 6, June 1979, p. 36-42.

Kilometer-diameter antennas could be used in this super system to transmit power to ground-based rectifying antennas.

**A80-23219** The development of solar power satellites. P. E. Glaser (Arthur D. Little, Inc., Cambridge, Mass.; Sunsat Energy Council, Washington, D.C.). In: Advances in energy systems and technology. Volume 2. (A80-23218 08-44) New York, Academic Press, Inc., 1979, p. 1-48. 49 refs.

The SPS concept is reviewed with particular attention given to technology options for conversion in space (photovoltaic and thermal-electric) and for power transmission to earth (microwave and laser transmission). Also discussed are SPS in the space transportation system, orbital assembly and maintenance, SPS/utility power pool interface, and SPS economic considerations and environmental impacts.

B.J.

**A79-37844** Satellite solar power stations - Current status and prospects. P. O. Collins (Imperial College of Science and Technology, London, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 21-25. 28 refs.

A brief review of the satellite solar power station concept is presented with attention given to technical environmental aspects. Cost estimates are discussed and consideration is given to the possible use of extraterrestrial materials and to UK interest in the project. B.J.

**CN-150,411** 1979  
**SPS IN-HOUSE DOCUMENTATION BIBLIOGRAPHY.**  
Jan. 1979. 23p.

Argonne National Lab.,  
Washington, D.C.

Satellite solar power station  
Bibliographies - Spacecraft, Power relay

## U.S. STUDY GRANT URGED FOR SOLAR POWER SATELLITE.

Aviation Wk. & Space Tech., Apr. 17, 1978, p. 19.

Washington—Sunsat Energy Council, formed to foster cooperative research and development of the solar power satellite concept, is asking for a \$200-million federal study over the next five years, which the organization hopes will lead to active subscale demonstration of the concept by the space shuttle.

Primary goal of the new group, composed of representatives of 25 major scientific and industrial organizations, is to increase awareness of the viability of the concept through educational programs to the public, the engineering community and Congress.

**N80-19631\*** Boeing Aerospace Co., Seattle, Wash.  
**SOLAR POWER SATELLITE SYSTEM DEFINITION STUDY.**  
**VOLUME 1, PHASE 2: EXECUTIVE SUMMARY Final Report**

Nov 1979 36 p Revised  
(Contract NAS9-15636)

(NASA-CR-160540: D180-25461-1-Vol-1-Rev-A) Avail: NTIS  
HC A03/MF A01 CSCL 10A

A review of solar energy conversion and utilization is presented. The solar power satellite system is then described. Overall system definition and integration is discussed. Principal reference system study accomplishments and conclusions are presented.

R E S

## ENERGY FOR EUROPE FROM SPACE?

D. Kassing and K.K. Reinhartz.

ESA Journal, v.2, 1978, p.179-187.

It is the purpose of this paper to discuss one of the few technical options Europe still has for providing large amounts of energy, namely the Solar Power Satellite (SPS), which can generate electrical power in space and transmit it to Earth as microwave energy. Numerous technical and economic studies have shown that, in principle, this concept could compete economically with other alternative advanced energy sources. The SPS has a major operational advantage over other solar-energy conversion schemes in that it can deliver base-load electrical energy almost constantly, with the exception of a small number of shadow periods (totalling less than one per cent per year), and it can also supply areas in Europe which have little sunshine but a highly developed industry, on an economic basis.

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507  
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v.61  
NASA Conference on Radiation Energy Conversion, 3d, Ames Research Center, 1978.  
Radiation energy conversion in space...  
c1978 (Card 3)

Chapter I The Solar Power Satellite System	1
The Solar Power Satellite Concept Evaluation Program ROBERT O. PILAND	3
SPS Microwave Subsystem Potential Impacts and Benefits RICHARD M. DICKINSON	25
Large Active Retrodirective Arrays for Solar Power Satellites RALPH CHERNOFF	36

#### SPS COST CONSIDERATIONS.

G.R. Woodcock.

J. Energy, v.2, no.4, July-Aug.1978, p.196-202.

ONE of the most significant solar power satellite (SPS) issues has been system costs, especially recurring (production) costs of SPS units to utilities. The present estimates of capital cost range from \$1700 to \$2700 per installed kilowatt (of useful ground output) for a modest-technology SPS system using silicon solar cells or potassium vapor Rankine heat engines (the latter, of course, employing solar concentrators). Since the installed kilowatts are base-load power rather than peaking or intermediate, the comparison with ground solar costs is potentially quite favorable.

#### ADVANCED PHOTOVOLTAIC SYNCHRONOUS-ORBIT SPACECRAFT POWER SYSTEMS

Paul Goldsmith and George M. Reppucci

J. Of Energy, vol. 2, no. 2, March-April 1978, p.81-84

IN this paper, we review state-of-the-art performance characteristics of synchronous-orbit power system components, discuss technology advancements, extrapolate overall system performance into the 1980-1990 time period, and finally, make alternative power system comparisons.

ESA SP-140

European Space Agency

#### PHOTOVOLTAIC GENERATORS IN SPACE

Proceedings of the First European Symposium on Photovoltaic Generators in Space, ESTEC, Noordwijk, The Netherlands (11-13 September 1978).

November 1978.

x + 318 pages, incl. numerous illustr. & ref.

36 papers in English; 1 paper in French.

This document contains contributions to the first European Symposium entirely devoted to the space application of photovoltaic energy conversion. This Symposium supplemented the Photovoltaic Solar Energy Conferences organised since 1977 by the Commission of the European Communities, and focussing in the terrestrial use of photovoltaic energy conversion. Attended by about 130 engineers and scientists from Europe, the USA, Canada and India, the Symposium gave a complete overview of the European solar array technology and a look into the future of photovoltaic energy conversion in space.

#### OUTPUT POWER VARIATIONS WITH SOLAR POWER SATELLITES,

by R. J. Gutmann.

Solar Energy, vol. 21, no. 4, 1978, p. 323-330.

The first comprehensive evaluation of output power variations expected from solar power satellites is presented. The various factors are classified in a two-tier manner as deterministic (either periodic or nonperiodic) and statistical (either constant with system life or changing with life). The largest variations are due to seasonal periodic factors, namely variations in the solar constant (plus or minus 3.3 per cent) and a solar illumination variation with the photovoltaic array held perpendicular to the orbit plane (plus or minus 4.2 per cent). Other key factors delineated which are being quantified presently include power reductions due to microwave power-tube failure and silicon solar cell radiation damage, while multiple shadowing of adjacent power stations in geosynchronous orbit and rectenna structural factors and combining efficiency variations are representative of areas that need further study. (Author)

NASA CR-3044

1976

#### Satellite solar power stations

RESEARCH PLAN FOR STUDY OF BIOLOGICAL AND ECOLOGICAL EFFECTS OF THE SOLAR POWER SATELLITE TRANSMISSION SYSTEM. Bernard D. Hanson. Aug.1976. 304p.

Hanson (Bernard D.).

Los Alamos NITLs, Calif.

ECONOMIC AND ENVIRONMENTAL COST OF SATELLITE  
SOLAR POWER  
Peter Glaser  
Mechanical Engineering  
Vol. 100, no. 1, January 1978  
pp. 32-37.

*The satellite solar power station is a concept that is being given increased attention by both engineers and the general public. But these stations must answer more than the question of technological feasibility. Economic viability, socio-economic impact, and environmental effects must also be taken into consideration.*

TL NASA Conference on Radiation Energy Conver-  
507 sion, 3d, Ames Research Center, 1978.  
.P75 Radiation energy conversion in space...  
v.61 c1978. (Card 2)

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	Energy Conversion at a Lunar Polar Site JAMES D. BURKE	95

THE FRANKLIN INSTITUTE HAS HIGH HOPES FOR ITS BIG  
BALLOON, by Ernest C. Okress.  
IEEE Spectrum, vol. 15, no. 12, December 1978,  
p. 41-46.

**A mile-long hot-air balloon is proposed  
for space research and solar power generation**

TL	NASA Conference on Radiation Energy Conver-	
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VIENS CHANGE ON POWER SATELLITE WORK.  
Craig Covault  
Aviation Week & Space Technology, Vol. 109,  
No. 3, July 17, 1978, p. 42-46.

CN-142,941 1978  
FUTURE SPACE PROGRAMS. (Hearings before the  
Committee on Science and Technology, U.S. House of  
Representatives, 95th Congress, 2nd Session, Jan.  
24-26, 1978). 1978. 986p.

95th Congress, 2nd Session  
95th Congress, 2nd Session No. 63  
Committee on Science and Technology

Spacecraft, Future  
Hearings - Committee on Science & Technology  
Research - Space

*Space solar power & our  
Energy/economic crisis, p.317.*

*Solar power satellite development:  
a time for decision, p.600 -*

A78-36705 \* Solar power satellite construction concepts. K.  
H. Miller (Boeing Aerospace Co., Seattle, Wash.). In: The industrial-  
ization of space; Proceedings of the Twenty-third Annual Meeting,  
San Francisco, Calif., October 18-20, 1977. Part 1. (A78-  
36701 15-12) San Diego, Calif., American Astronautical Society;  
Univelt, Inc., 1978, p. 79-99. Contract No. NAS9-15196. (AAS  
77-203)

In-space construction of a photovoltaic solar power satellite that  
is 5 1/2 by 25 km in size and weighs 81,000 tons is discussed. One of  
the construction approaches being considered requires 1/8-size power  
collection satellite modules to be constructed in low earth orbit  
(LEO) and transported to geosynchronous orbit (GEO) using  
self-powered electric thrusters. At GEO, these 1/8-size modules are  
connected and the antenna is constructed and attached. This  
construction approach will require about 300 people at LEO and 380  
people at GEO working 10 hour shifts for 90 day staytimes. This  
paper describes the construction operations and construction equip-  
ment. Also discussed are some of the human factors considerations.

(Author)

STRUCTURES FOR SOLAR POWER SATELLITES, by Ralph H.  
Nansen and Harold Di Ramio  
Astronautics & Aeronautics, vol. 16, no. 10, October  
1978, p. 55-59

In a useful size, a solar power satellite (SPS)—a  
large electrical-power generating system in a geo-  
synchronous orbit transmitting energy to Earth by  
microwave beam—has output at the ground inter-  
face between 5 and 10 gigawatts (gw). An SPS  
might use one of several methods of energy conver-  
sion—photovoltaic (solar cells at various concentra-  
tion ratios), closed-cycle thermal engine, and  
thermionic—and these have been evaluated over the  
past several years. The currently preferred energy-  
conversion system, photovoltaic, uses annealable  
solar cells and no reflective concentrators, yielding  
a planar satellite as the baseline concept. Two an-  
tennas, one at either end of the satellite, together  
provide 5-gw useful output to two independent re-  
ceiving stations on Earth.

CN-150,291 1978  
SPACE SHUTTLE 1979. (Status Rpt. for the  
Committee on Science and Technology, U.S. House  
of Representatives, 95th Congress, 2nd Session,  
Dec. 1978). 1978. 671p. (Committee Print).

95th Congress, 2nd Session  
95th Congress, 2nd Session Serial 77  
Committee on Science and Technology

Space shuttle  
Hearings - Committee on Science & Technology

*Space solar power system*  
SER 97-73



CN-150,123 1978  
LOGISTICS COSTS OF SOLAR POWER SATELLITES. R.H. Miller and D.L. Akin, MIT. (Presented at 29th Congress of IAF, Dubrovnik, Yugoslavia, Oct.1-8, 1978). Sept.1978. 24p.

International Astronautical Federation IAF Paper 78-195  
International Astronautical Congress Oct.1-8, 1978

### Satellite solar power stations Spacecraft - Cost

AN APERTURE-AUGMENTED PROTOTYPE POWER SATELLITE,  
by K. E. Drexler and B. R. Sperber  
Journal of Energy, vol. 2, no. 5, September 1978,  
p. 318-319

**T**O demonstrate the feasibility of power satellites at a minimum of cost and risk, most agree that the development program should include a subscale prototype. A prototype which would test the technically risky parameters of the microwave power transmission system at their full-scale values while greatly relaxing other parameters to reduce total system cost could prove attractive.

NASA CP-2035, v.1 1978  
Spacecraft, Power-relay  
LARGE SPACE SYSTEMS TECHNOLOGY. E.C. Naumann, LaRC and A. Butterfield, General Electric Co., comp.  
(An Industry/Government Seminar held at NASA LaRC, Jan.17-19,1978). May 1978. 1092p.

Seminar on Large Space Systems Technology Jan.17-19, 1978

FUTURE LARGE SPACE SYSTEMS OPPORTUNITIES - A CASE FOR SPACE-TO-SPACE POWER? p.507  
L. B. Garrett and W. R. Hook

NASA CP-2058

1978

Spacecraft, Power relay  
FUTURE ORBITAL POWER SYSTEMS TECHNOLOGY REQUIREMENTS.  
(Symposium held LaRC, May 31-June 1,1978). Sept.1978. 322p.

Symposium on Future Orbital Power Systems Technology Requirements May 31-June 1, 1978

SATELLITE POWER SYSTEMS PROGRAM  
Ralph I. LaRock, NASA Headquarters p.107..

WORKSHOP ON ENVIRONMENTAL INTERACTIONS WITH LARGE ORBITAL POWER SYSTEMS . . . p.309. . . . .

CN-150,011 1978  
SOLAR POWER SATELLITE. (Hearings before the Subcommittee on Space Science and Applications and the Subcommittee on Advanced Energy Technologies and Energy Conservation Research, Development and Demonstration of the Committee on Science and Technology, U.S. House of Representatives, 95th Congress, 2nd Session, Apr.12-14,1978). 1978. 450p.

95th Congress, 2nd Session No.63  
95th Congress, 2nd Session  
Committee on Science and Technology

Satellite solar power stations  
Power transmission, Microwave  
Human engineering & physiology - Radiation  
Report of the solar power satellite task group, p.36-  
Solar power satellites: a viable energy option, p.287-  
Solar power satellite development - The Next Step, p.306-  
Solar power satellite revisited, p.416-  
Energy analysis of solar satellite power station, p.429-

## Radiation Energy Conversion in Space

Kenneth W. Billman  
Editor

1978

The principal theme of this volume is the analysis of potential methods for the effective utilization of solar energy for the generation and transmission of large amounts of power from satellite power stations down to Earth for terrestrial purposes. During the past decade, NASA has been sponsoring a wide variety of studies aimed at this goal, some directed at the physics of solar energy conversion, some di-

rected at the engineering problems involved, and some directed at the economic values and side effects relative to other possible solutions to the much-discussed problems of energy supply on Earth. This volume constitutes a progress report on these and other studies of SPS (space power satellite systems), but more than that the volume contains a number of important papers that go beyond the concept of using the obvious stream of visible solar energy available in space. There are other radiations, particle streams, for example, whose energies can be trapped and converted by special laser systems. The book contains scientific analyses of the feasibility of

Open

using such energy sources for useful power generation. In addition, there are papers addressed to the problems of developing smaller amounts of power from such radiation sources, by novel means, for use on spacecraft themselves.

Physicists interested in the basic processes of the interaction of space radiations and matter in various forms, engineers concerned with solutions to the terrestrial energy supply dilemma, spacecraft specialists involved in satellite power systems, and economists and environmentalists concerned with energy will find in this volume many stimulating concepts deserving of careful study.

Martin Summerfield  
Series Editor

IEEE Proceedings, v.66, no.3,  
p.276-289.

Mar.  
1978

SPACE SOLAR ENERGY STATION.

## N79-30750\* Boeing Aerospace Co., Seattle, Wash SOLAR POWER SATELLITES: THE ENGINEERING CHALLENGES

G. R. Woodcock In ESA Photovoltaic Generators in Space  
Nov 1978 p 139-147 (For primary document see N79-30730  
21-44)

(Contract NAS9-15196)

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Certain elements of solar power satellite design and system engineering studies are reviewed analyzing solar power satellites as a potential baseload electric power source. The complete system concept includes not only the satellites and their ground stations, but also the space transportation for delivery of the satellites, piece by piece, into space, and the factories for their construction in space. Issues related to carrying the solar power satellite concept from the present design study phase through implementation of actual hardware are considered. The first issue category is environmental aspects of the SPS systems. The second category of issues is the technology risks associated with achieving the necessary component and subsystem performances. The third category includes the engineering issues associated with carrying out such a large scale project. The fourth issue category is financial: the funding required to bring such a project into being and the costs of the satellites and resulting cost of the power produced as compared to potential alternative energy sources.

Author (ESA)

## THE SOLAR POWER SATELLITE CONCEPT: A SPACE PROGRAM PERSPECTIVE.

C.C. Kraft Jr.

J. Energy, v.2, no.4, July-Aug.1978, p.193-195.

The development of a solar power satellite would represent an undertaking of significant magnitude and difficulty; consequently, considerable care must be exercised before committing major resources to this course of action. It should be recognized that those individuals and groups involved in the study of the concept do not believe there should be an immediate commitment to build full-scale solar power satellites; instead, they recommend conducting those activities which will enable thorough evaluation of the technology and economics of the concept. Consequently, considerable thought has been given to how these evaluation activities should be conducted in the context of a total space program. Surprisingly (or not), the space activities needed to explore and evaluate the solar power satellite concept have a commonality with other future space applications, and this commonality serves as a basis for developing an integrated approach to a future space program. The concept for such an integrated approach is discussed briefly in the remainder of this paper.

ORIGINAL PAGE IS  
OF POOR QUALITY

SOLAR POWER SATELLITE DEVELOPMENTS, by Peter E. Glaser  
The Journal of the Astronautical Sciences, vol. 26,  
no. 2, April-June 1978, p. 101-127

The terrestrial solar energy conversion methods capable of generating power continuously are reviewed and the rationale for solar energy conversion in geosynchronous orbit is outlined. The principles of the concept of solar power satellites (SPS) are presented and the technology options for converting solar energy in space, transmitting microwave power, and converting it on Earth into electricity, are summarized. The development of the design concept of the SPS, based on solar thermal and photovoltaic conversion, is examined and salient characteristics are provided. The details of microwave power generation, beam transmission, and conversion to DC at the receiving antenna on Earth are discussed. The requirements for a space transportation system, orbital construction and assembly, maintenance and operations are reviewed. The environmental impacts of SPS operation, such as stratospheric emission by space vehicles and atmospheric attenuation and scattering, ionospheric interactions, and biological effects of the microwave beam are highlighted. Economic and social issues are considered and the potential contribution of the SPS to meet future energy demands is projected.

A78-21266 # A development strategy for the solar power satellite. D. L. Gregory (Boeing Aerospace Co., Seattle, Wash.). American Astronautical Society, Anniversary Conference, 25th, Houston, Tex., Oct. 30-Nov. 2, 1978, Paper 78-154, 26 p.

An interdisciplinary study examined several problems associated with the solar power satellite (SPS) project, and the number of primary individual shuttle flights required to test the SPS concept is considered. It is suggested that a single sortie for launching a single large aperture satellite should be sufficient for providing proof of SPS concepts. The satellite and its role in studying developmental operations are described. After this project, which could be organized by about 1983, a later project, designed to assure success of major flight projects, would involve three shuttle flight sorties to study a structural beam 'machine', an orbital work station, and high power elements.  
M.L.

STRUCTURES FOR SOLAR POWER SATELLITES, by Ralph H. Nansen and Harold DI Ramio.  
Astronautics & Aeronautics, vol. 16, no. 10, October 1978, p.55-59.

Either tapered-tube or continuous-chord construction suits the baseline photovoltaic planar array; further technology development will decide between them

## SATELLITE POWER SYSTEM LEO vs GEO ASSEMBLY ISSUES

J. of Energy  
Vol. 2 no.1  
p. 40-45

JAN.-FEB,  
1978

THE productivity of man in space has been identified<sup>1</sup> as a major cost and risk driver for a satellite power system. A major issue influencing both productivity and overall system costs is the approach selected for assembly and construction of an SPS vehicle. Inherent within this issue is the location of the SPS construction facility in space. Should the SPS be constructed in LEO or GEO; or should it be partially assembled in LEO and transported to GEO for final assembly? Clearly, a broad assortment of construction scenarios could be conceived.

This paper addresses some fundamental considerations that bear upon the SPS construction location issue.

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153  
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1978

Energy Technology Conference, 5th, Washington, D.C., 1978.

Energy technology V : challenges to technology : proceedings of the fifth Energy Technology Conference, February 27-March 1, 1978, Washington, D.C. / edited by Richard F. Hill. -- Washington : Government Institutes, 1978.

xiii, 1063 p. : ill.

1. Power (Mechanics)—Congresses.

## SOLAR POWER SATELLITES REVISITED

James E. Drummond, Vice President, Power Conversion Technology, Inc.

p.487

A79-31921 # A review of some critical aspects of satellite power systems. I. V. Franklin (British Aerospace, Dynamics Group, Weybridge, Surrey, England) and A. W. Rudge (Electrical Research Association, Ltd., RF Technology Centre, Leatherhead, Surrey, England). In: Energy and aerospace. Proceedings of the Anglo-American Conference, London, England, December 5-7, 1978. (A79-31908 12-44) London, Royal Aeronautical Society, 1979. 18 p. 13 refs.

Some critical aspects of the Solar Power Satellite (SPS) are considered. The basic concepts of the SPS are considered along with aspects of SPS delivery and construction systems, solar arrays, on board electrical power collection, costs, European activities, and questions of development strategy. The SPS microwave system is examined, taking into account basic operations and constraints. The baseline microwave system, major areas of uncertainty, and the space antenna.  
G.R.



TECHNICAL CONSIDERATIONS FOR SOLAR POWER SATELLITES,  
by R. O. Piland.  
ACTA Astronautica, vol. 5, no. 10, October 1978,  
p. 877-897.

**Abstract**—Requirements for energy continue to increase and alternate sources are being actively pursued. Solar energy is an obvious candidate for consideration. The increasing costs of other energy sources will make solar energy more attractive. A new concept for the collection of solar energy has been developed, involving the location of solar power stations in space. This location provides for near continuous access to solar energy unhindered by the atmosphere, cloud cover, or the day-night cycle.

Studies have indicated the technical feasibility of the concept with its economic viability dependent upon the degree of technology advancement assumed. Numerous areas requiring further analysis have also been identified, as well as the need for ground and space pre-development projects. The pre-development projects would provide the information and experience on which to base a decision as to the desirability of a full-scale space solar power program.

The present paper will present the results of recent investigations of critical technical areas and a description of a series of pre-development space projects. The technical areas include space construction techniques, construction location (low earth orbit vs geosynchronous orbit) and the large cargo-carrying, earth-to-space transportation systems. The pre-development space activities include microwave system tests, construction techniques and equipment verification, and the conduct of manned inter-orbit operations.

CN-142,941 1978  
FUTURE SPACE PROGRAMS. (Hearings before the  
Committee on Science and Technology, U.S. House of  
Representatives, 95th Congress, 2nd Session, Jan.  
24-26, 1978). 1978. 986p.

95th Congress, 2nd Session  
95th Congress, 2nd Session No. 63  
Committee on Science and Technology

Spacecraft, Future  
Hearings - Committee on Science & Technology  
Research - Space

*Space Solar Power & Our Energy/Economic  
Crisis P. 311*  
*Solar Power Satellite Development  
A Time for Decision p. 60*

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Greater Los Angeles Area Energy Symposium, Los  
Angeles, 1978.

Greater Los Angeles Area Energy Symposium  
: Tuesday, May 23, 1978 ... Los Angeles,

\* Satellite Power System (SPS) Preliminary  
Environmental Impact Assessment — Floyd R. Livingston, Jet Pro-  
pulsion Laboratory

*P241*

The National Aeronautics and Space Administration (NASA), Office of Energy Programs, is presently conducting a study of the potential utility of using large satellite power stations as energy sources for terrestrial needs. As a part of this study, the Jet Propulsion Laboratory has been requested to perform an analysis of the Potential Impacts and Benefits arising from the implementation of a Satellite Power System (SPS) network. This analysis is part of the data base being developed by NASA and the Department of Energy (DOE) for use in making a decision on whether to proceed with the next program phase of SPS.

NSO-16484\* National Aeronautics and Space Administration,  
Washington, D. C.

SATELLITE POWER SYSTEM (SPS)

Henry G. Edler Oct 1978 20 p refs

(Contract EG-77-C-02-4042)

(NASA-TM-80943 TID-29094)

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HC A02/MF A01 CSCL 10A

Potential organizational options for a solar power satellite system (SPS) were investigated. Selection and evaluation criteria were determined to include timeliness, reliability, and adequacy to contribute meaningfully to the U.S. supply, political feasibility (both national and international), and cost effectiveness (including environmental and other external costs). Based on these criteria, four organizational alternatives appeared to offer reasonable promise as potential options for SPS. A large number of key issues emerged as being factors which would influence the final selection process. Among these issues were a variety having to do with international law, international institutions, environmental controls, economics, operational flexibility, congressional policies, commercial vs governmental ownership, national dedication, and national and operational strategic issues.

RES

Satellite Power System (SPS)

by Henry G. Edler

U.S. Department of Energy report TID-29094, October 1978

Under contract no. EG-77-C-01-4024

16 pages

An overview of prospective organizational structures in the solar power satellite field.

TL AAS Annual Meeting, 24th, Washington, D.C., 1978  
 787 1978 *Solar power satellite system*  
 -A2 Space shuttle and spacelab utilization  
 v.37 ... 1978 (card 2)  
 pt.1 At head of title: An American Astronautical  
 tical Society publication.  
 Includes bibliographical references.  
 ISBN 0-87703-096-0  
 1. Reusable space vehicles--Congresses.  
 2. Orbiting astronomical laboratories--  
 Congresses. I. Morganthaler, George W.  
 III. Holstein, Manfred. III. Goddard  
 (Continued on card

Solar Power Satellite Developments (AAS 78-022)  
 Peter E. Glaser

1287

Royal Society of London  
 Philosophical Transactions,  
 Ser. A, v.295, no.1414

Feb. 7,  
 1980

SOLAR ENERGY. (A discussion held Nov. 15-16, 1978.  
 Organized by George Porter and William Hawthorne).

B. ANDERSON AND SIR BERNARD LOVELL, F.R.S.

P507-511

Effect of solar power satellite transmissions on radio-astronomical research  
 Solar power satellites (s.p.s.) now in the research and development stage are intended to be placed in geostationary orbits where large arrays of photocells will collect solar energy which will be delivered to Earth on a frequency of 2.45 GHz at a power level of 10 GW. The calculations in this paper indicate that severe restrictions will be placed on the use of radio telescopes on Earth for the study of radio emissions from celestial objects. For a single s.p.s. it would be possible to operate with the radio receiver protected by suitable filters at radio frequencies well separated from 2.45 GHz and at angles of look well displaced from the s.p.s. However, operational systems involving many s.p.s. to supply significant amounts of power to Earth would create serious hazards to radio-astronomical research, except possibly in thinly populated areas of the Earth.

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 1978

Institute of Electrical and Electronics  
 Engineers. Region 5.

Energy 78 : 1978 Region Five annual  
 conference, April 16-18, 1978, Tulsa,  
 Oklahoma /co-sponsors : IEEE Region V  
 Tulsa Section, PES-IAS Chapter. -- New  
 York : Institute of Electrical and Elec-

Design Considerations for Solar Power Satellites P.153  
 G. D. Arndt, L. Leopold, Johnson Space Center

Attitude & Pointing Control System for the Microwave Antenna  
 of the Solar Power Satellite P.158  
 M. Y. Wu, University of Colorado

A79-31925 \* # The Solar Power Satellite concept - Towards  
 the future. C. C. Kraft, Jr. (NASA, Johnson Space Center, Houston,  
 Tex.). In: Energy and aerospace; Proceedings of the Anglo/American  
 Conference, London, England, December 5-7, 1978. (A79-  
 31908 12-44) London, Royal Aeronautical Society, 1979. 12 p.

An evolutionary program phasing with respect to the develop-  
 ment of a Solar Power Satellite (SPS) is considered, taking into  
 account concept identification, concept evaluation, exploratory  
 research, space technology projects, system development, and  
 commercial operations. At the present time the concept evaluation  
 phase of the program is underway. This phase is scheduled for  
 completion in 1980. It will result in a recommendation as to whether  
 the concept should be explored further and if so, in what manner.  
 The recommendation will be based on technical feasibility, economic  
 and environmental considerations, and comparisons with other  
 potential systems of the future. It is premature to speculate on the  
 conclusions and recommendations from the evaluation program as to  
 whether the program should proceed to the next phase. G.R.

A79-31919 # Status of the SPS concept development and  
 evaluation program. F. A. Koomanoff (U.S. Department of Energy,  
 Satellite Power Systems Projects Office, Washington, D.C.). In:  
 Energy and aerospace; Proceedings of the Anglo/American Confer-  
 ence, London, England, December 5-7, 1978. (A79 31908 12-44)  
 London, Royal Aeronautical Society, 1979. 17 p.

The Satellite Power System (SPS) is designed to capture solar  
 radiation in geosynchronous orbit and, by means of photovoltaics,  
 convert the solar energy to electrical energy. The current status of  
 the SPS program is discussed by describing the systems definition  
 activities, environmental and societal assessment activities, and the  
 comparative assessment directions. The organization and funding for  
 these activities are also presented. It is concluded that to date no  
 program stoppers have been found, however, many significant  
 questions remain unanswered; questions which must be answered  
 before the next steps may be reached in determining if SPS is indeed  
 an energy option for mankind. G.R.

TECHNOLOGY AND DEVELOPMENT REQUIREMENTS OF THE SOLAR POWER SATELLITE, by Richard L. Kline  
Journal of Energy, vol. 2, no. 5, September 1978, p. 303-308

This paper discusses three major technology and development issues (energy conversion, microwave power transmission system and ground receiver, and construction) which must be addressed to achieve solar power satellite (SPS) operational capability. The technology and development issues center about economical operation of the SPS and identify requirements for such a program from the near term to the mid-1980's. For each of the issues, current status is described and critical considerations which must be addressed are identified. Hardware under development and their evolution/utilization are also described. A timetable for an SPS program, together with a key technology and development step, the power technology module (PTM), are detailed. Based on the identified requirements, a three-step technology and development program, consisting of a ground technology phase, a Shuttle sortie mission phase, and a PTM phase, is recommended.

A79-31920 # Solar Power Satellite systems definition. G. R. Woodcock (Boeing Aerospace Co., Seattle, Wash.). In: Energy and aerospace; Proceedings of the Anglo/American Conference, London, England, December 5-7, 1978. (A79-31908 12-44) London, Royal Aeronautical Society, 1979. 47 p.

A summary is provided of the results obtained in a detailed investigation of the technical and cost feasibility of Solar Power Satellites (SPS). Attention is given to SPS configuration options, the photovoltaic energy conversion, a recommended gallium arsenide satellite concept, the radiation degradation of solar cells, questions of power distribution, microwave power transmission, microwave generation technology, phase control, the power receiver system, ground-based power processing technology, laser power transmission, space transportation to low earth orbit, space-based construction and transportation operations, costing methods, cost analysis methodology, SPS cost ranges, economic analyses, resources requirements, and aspects of development and implementation. G.R.

A79-16468 # Use of satellites in solar applications. H. W. Hiser (Miami, University, Coral Gables, Fla.). In: International Symposium-Workshop on Solar Energy, Cairo, Egypt, June 16-22, 1978, Symposium Lectures. (A79-16451 04-44) Coral Gables, Fla., University of Miami, 1978, p. 395-408, 17 refs.

Of the two solar satellite applications discussed in the present paper, one is intended for obtaining detailed global maps of available solar energy; the other application is to provide platforms for solar power stations in space that will beam electric energy to earth by microwave transmission. Equatorial geostationary meteorological satellites can provide continuous monitoring of solar energy between 55 deg N and 55 deg S latitude. Polar orbiting satellites can provide similar coverage at high latitudes, however, the coverage is discontinuous, and depends on orbiting times. Both types of satellite monitor cloud cover. The cloud data are used to compute sunshine and solar energy. The solar power station concept uses geostationary satellites with collectors to convert solar energy directly to electricity by the photovoltaic process. V.P.

A79-31922 # Preliminary assessment of the environmental impacts of the Satellite Power System (SPS). S. L. Halverson, D. M. Rote (Argonne National Laboratory, Argonne, Ill.), C. M. Rush (National Telecommunications and Information Administration, Institute for Telecommunication Sciences, Boulder, Colo.), K. Davis (Battelle Pacific Northwest Laboratories, Richland, Wash.), M. White (California, University, Berkeley, Calif.), and D. F. Cahill (U.S. Environmental Protection Agency, Research Triangle Park, N.C.). In: Energy and aerospace; Proceedings of the Anglo/American Conference, London, England, December 5-7, 1978. (A79-31908 12-44) London, Royal Aeronautical Society, 1979. 17 p.

Investigations required to assess the health and ecological effects of microwaves are considered. In addition to the impacts of microwaves, a number of other health and safety effects can be anticipated from the deployment of a Solar Power Satellite (SPS). Factors that are unique to the SPS deployment are related to the handling of large quantities of gallium arsenide for solar cells and the exposure of construction workers to extended periods of space radiation. Attention is also given to the effects on the atmosphere, aspects of electromagnetic compatibility, and ionospheric heating and vehicle effluent effects. G.R.

A79-31923 # European aspects of Solar Satellite Power systems. M. Trella and K. K. Reinhartz (ESA, Noordwijk, Netherlands). In: Energy and aerospace; Proceedings of the Anglo/American Conference, London, England, December 5-7, 1978. (A79-31908 12-44) London, Royal Aeronautical Society, 1979. 17 p. 18 refs.

It is pointed out that energy-related problems are potentially much more serious in Europe than in the U.S. The proposal is, therefore, made that European countries should investigate the prospects offered by the SPS as a future source of a part of the energy needed by them. An outline is presented of the specifically European problems which have to be investigated to evaluate the SPS concept. Possible European activities are examined, taking into account a concept evaluation, studies related to energy conversion, space construction and operation, power transmission and distribution, transportation, and the selection criteria for technological research. Program considerations and financial aspects are also explored. G.R.

A79-21205 # An evolutionary solar power satellite program. G. M. Hanley and W. R. Rhotel (Rockwell International Corp., Satellite Systems Div., Downey, Calif.). American Astronautical Society, Anniversary Conference, 25th, Houston, Tex., Oct. 30-Nov. 2, 1978, Paper 78-153. 19 p.

An evolutionary solar power satellite (SPS) development plan was prepared to satisfy stated objectives. In this paper, effort is mainly directed to amplification of the technology advancement phase of the SPS development plan for the projected time frame 1980-1990. The discussion focuses on the microwave exploratory research program, the SPS power conversion/distribution and structures technology, the SPS orbital test platform evolution at low earth orbit and geosynchronous earth orbit, and the pilot plant demonstration phase. A well-focused ground test program supported by key Shuttle sortie experiments during the period 1980-1985 can lead to the evolution of the SPS orbital test platform during the latter part of the decade. Completion of the SPS technology advancement phase of SPS development in 1990 will provide the technical confidence to proceed with the full-scale pilot plant demonstration phase. S.D.

N80-14478# PRC Energy Analysis Co., McLean, Va.  
SATELLITE POWER SYSTEM (SPS): AN OVERVIEW OF PROSPECTIVE ORGANIZATIONAL STRUCTURES IN THE SOLAR SATELLITE FIELD  
H. G. Edler Oct. 1978 19 p refs  
(Contract EG-77-C-01-4024)  
(TID-29094) HC A02/MF A01

A literature survey, interviews with acknowledged experts in the fields of organizational entities, space, solar energy, and the SPS concept, and an analysis of these inputs to identify the organizational alternatives and make judgments as to their feasibility to serve as patterns for a future SPS entity are presented. Selection and evaluation criteria were determined to include timeliness, reliability, and adequacy to contribute meaningfully to the U.S. supply; political feasibility (both national and international) and cost-effectiveness (including environmental and other external costs). Based on these criteria, four organizational alternatives are discussed which offer reasonable promise as potential options for SPS. These included three domestic alternatives and one international alternative. DOE



## SPACE-BASED SOLAR POWER STUDY NEAR COMPLETION

Benjamin M. Elson  
Aviation Week & Space Technology  
Vol. 107, no. 12, September 19, 1977,  
p. 58-69.

**Kent, Wash.**—Researchers here are nearing completion of an effort to refine the definition of a space-based solar power system capable of generating competitively priced electricity in commercial quantities before the year 2000.

Economic considerations have focused attention on very large satellite systems capable of producing 5,000-10,000 megawatts at the busbars of the energy receiving stations on the ground—5-10 times the capacity of the largest nuclear power plants. Orbiting power stations of such capacity might range up to 150 sq. km. in size and weigh close to 80,000 metric tons, analysts here said. Building and maintaining such vast structures will entail the development of wholly new modes of space operations as well as a new generation of launch and orbital transfer vehicles. Construction of such a satellite might, for example, require the launch of one heavy-lift launch vehicle every working day for a year.

Astronautics & Aeronautics, v.15, no.11, Nov.1977.

### 36 GSSPS: TAKING A NEW APPROACH TO THE SPACE SOLAR POWER STATION

Leopold J. Cantafio, Vladimir A. Chobotov, and Malcolm G. Wolfe

*A gravity-gradient-stabilized station passively controlled illustrates the importance of innovation and synergistic technology in pursuing this major energy option.*

TJ New options in energy technology / sponsored  
163.2 by the American Institute of Aeronautics and  
.N47 Astronautics, Edison Electric Institute, IEEE  
Power Engineering Society, -- New York :  
American Institute of Aeronautics and Astro-  
nautics, c1977.

149 p. : ill. ; 29 cm.

Papers nos. 77-1004-771034

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Transmission of Power from Space to Earth - W. C. BROWN.....p.106

Satellite Solar Power -- Will it Pay Off? - G. A. HAZELRIGG JR....p.117

Satellite Power System LEO vs GEO Assembly Issues - J. MOCKOVCIK, JR. and  
R. J. ADORNATO.....p.124

N78-21812# National Aeronautics and Space Administration.  
Lyndon B. Johnson Space Center, Houston, Tex.

#### SOLAR POWER SATELLITES

Christopher C. Kraft, Jr. [1977] 7 p

(NASA-TM-79434) Avail. NTIS HC A02/MF A01 CSCL 10A

A satellite based energy concept is described, including the advantages of the basic concept, system characteristics, cost, and environmental considerations. An outline of a plan for the further evaluation and implementation of the system is given. It is concluded that the satellite concept is competitive with other advanced power generation systems when a variety of factors are considered, including technical feasibility, cost, safety, natural resources, environment, baseload capability, location flexibility, land use, and existing industrial base for implementation. Author

#### SOLAR POWER SYSTEMS

Jesse C. Denton

Energy Conversion, vol. 16, no. 4, 1977, p. 181 -  
198

**Abstract**—A review of the principal solar power systems is presented. The nature of the solar energy source is discussed starting from the energy output of the sun and covering briefly the important atmospheric effects to characterize the available solar energy on the earth's surface. The various methods for capturing solar energy are presented: flat-plate, concentrating, photovoltaic, and other collectors. Energy storage methods are presented briefly for thermal, chemical, electrical, and mechanical storage approaches. An application of solar power systems in interaction with a conventional electrical utility system is presented in terms of mode of operation (base, intermediate, and peaking), reliability, capacity displacement, and energy displacement. An economic evaluation of selected solar power systems compared to conventional electrical generation plants is presented. Conclusions are drawn as to the conditions under which solar power systems may become economically competitive. A preliminary indication of market capture potential is discussed.

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Intersociety Energy Conversion Engineering  
Conference, 12th, Washington, 1977.  
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A. Caluori, H. Oman, Boeing Aerospace Co.,  
Seattle, Wash. .... 1378
- 779232 — Thermal Engine Solar Power Satellites,  
D. L. Gregory, Boeing Aerospace Co., Seattle,  
Wash. .... 1386
- 779233 — Solar Power Satellites—A System Ov-  
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A. Hazelrigg, Jr., ECON, Inc., Princeton, N.J. . 1421

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Princeton/AIAA Conference on Space Manufac-  
turing Facilities, 3d, Princeton, N.J., 1977.  
Space manufacturing facilities II : pro-  
ceedings of the Third Princeton/AIAA Con-  
ference May 9-12, 1977 / edited by Jerry  
Grey. — New York : American Institute of  
Aeronautics and Astronautics, 1977.  
xi, 356 p. : ill.

Space Solar Power—The Transportation Challenge/Hubert P. Davis, NASA  
Space Center p. 35 -

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Intersociety Energy Conversion Engineering  
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sues and Needed Technology, C. A. Nathan,  
Grumman, Bethpage, L.I., N.Y. .... 1428
- 779240 — The Evolution of the Photovoltaic Gravi-  
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Power Station, L. J. Cantafio, V. Chobotov, M.  
G. Wolfe, Aerospace Corp., El Segundo, Calif. 1437
- 779241 — Space-Borne Power Conversion into a  
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ronment of the Upper Atmosphere, O. E. May-  
nard, A. H. Katz, Raytheon Co., Sudbury, Mass.;  
W. E. Whitacre, NASA/Marshall, Huntsville, Ala. 1445
- 779242 — Thermoelectronic Laser Energy Con-  
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C. Yuen, Rasor Assoc., Inc., Sunnyvale, Calif. 1453
- 779243 — Optimizing a Low Cost Satellite Energy  
System, J. E. Drummond, Maxwell Lab., Inc.,  
San Diego, Calif. .... 1461
- 779244 — Comparative Assessment of Orbital and  
Terrestrial Central Power Plants, R. Caputo, Jet  
Propulsion Lab., Pasadena, Calif. .... 1468
- Space Construction Base Operations in Support  
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1976

SURVEY OF FUTURE REQUIREMENTS FOR LARGE SPACE  
STRUCTURES. John M. Hedgepath. (Final rept.).  
Jan. 1976. 52p.

Astro Research Corp.  
Santa Barbara, Calif.  
NASA NAS1-13178

TL Princeton University Conference, [Princeton,  
797 N.J.] 1975.  
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1975 colonies) ... c1977. (Card 2)  
Bibliography: p. 261-266; A71-72.  
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Solar energy. 3. Lagrange equations.  
I. American Institute of Aeronautics

Development of the Satellite Solar Power Station/Peter E. Glaser, Arthur D. Litt  
p. 115

Closed Brayton Cycle Turbines for Satellite Solar Power Stations/Gordon R.  
The Boeing Company p. 129

**An Initial Comparative Assessment of Orbital and Terrestrial Central Power Systems.**

R. Caputo.  
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena. 15  
Mar 77, 158p NASA-CR-155042, JPL-PUBL-77-44  
N77-32594/2WE Price code: PC A08/MF A01

A silicon photovoltaic orbital power system, which is constructed from an earth source of materials, is compared to likely terrestrial (fossil, nuclear, and solar) approaches to central power generation around the year 2000. A total social framework is used that considers not only the projection of commercial economics (direct or in internal costs), but also considers external impacts such as research and development investment, health impacts, resource requirements, environment effects, and other social costs.

A78-18750 \* # Solar power satellite status report. H. P. Davis (NASA, Johnson Space Center, Houston, Tex.). *Texas Solar Energy Society, Conference on Solar Energy in the Southwest '77, Dallas, Tex., Aug. 27, 28, 1977, Paper.* 17 p.

The development of a solar power satellite program is considered. It is suggested that the solar power satellite is an engineering rather than a science program - that is, that no scientific breakthroughs are required before initiating the project. Available technology is examined, and several key questions are discussed: how efficient is microwave transfer of energy; how feasible is construction in space; and will the advantages of continuous insolation compensate for the costs of building a solar power plant in synchronous orbit 23,000 miles above the earth.  
M.L.

**PHOTOVOLTAIC, GRAVITATIONALLY STABILIZED, SOLID STATE SATELLITE SOLAR POWER STATION.**

L.J. Cantafio, et al.

J. Energy, v.1, no.6, Nov/Dec.1977, p.352-363.

A novel approach that was proposed during a NASA-funded study<sup>6</sup> is the gravitationally stabilized SSPS (GSS<sup>2</sup>PS) in which, for a photovoltaic system, the large solar array is separated into smaller segments or subunits, joined together in a linear array oriented along the local vertical. Earth pointing of the power transmitting antenna is achieved by locating it at the lower end of the solar array.

**An Initial Comparative Assessment of Orbital and Terrestrial Central Power Systems.**

R. Caputo.

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena. Mar 77, 160p NASA-CR-152688, JPL-DOC-900-780  
N77-22612/4WE PC A08/MF A01

Orbital solar power plants, which beam power to earth by microwave, are compared with ground-based solar and conventional baseload power plants. Candidate systems were identified for three types of plants and the selected plant designs were then compared on the basis of economic and social costs. The representative types of plant selected for the comparison are: light water nuclear reactor; turbines using low BTU gas from coal; central receiver with steam turbo-electric conversion and thermal storage; silicon photovoltaic power plant without tracking and including solar concentration and redox battery storage; and silicon photovoltaics.

**NASA PHILOSOPHY CONCERNING SPACE STATIONS AS OPERATIONS CENTERS FOR CONSTRUCTION AND MAINTENANCE OF LARGE ORBITING ENERGY SYSTEMS**

R. Freitag

J. of the British Interplanetary Society  
Vol. 30, no. 7, July 1977,  
p. 265-271.

**POWERSAT AN ASTRONAUTICAL ENERGY SOLUTION.**

Spaceflight, vol. 19, no. 3, March 1977, p. 82-89



TL Princeton/AIAA Conference on Space Manufac-  
797 turing Facilities, 3d, Princeton, N.J., 1977.  
.P65 Space manufacturing facilities II : pro-  
1977 ceedings of the Third Princeton/AIAA Con-  
ference May 9-12, 1977 / edited by Jerry  
Grey. — New York : American Institute of  
Aeronautics and Astronautics, 1977.  
xi, 356 p. : ill.

Assessment of Satellite Power Stations/Robert A. Summers and H. Richard Blieden, ERDA;  
and Charles E. Bloomquist, Planning Research Corporation p. 269-

N77-30612\*# Little (Arthur D.), Inc., Cambridge, Mass.  
EVALUATION OF SOLAR CELLS FOR POTENTIAL SPACE  
SATELLITE POWER APPLICATIONS Final Report  
1 Jun. 1977 56 p refs  
(Contract NAS9-15294)  
(NASA-CR-151498) Avail: NTIS HC A04/MF A01 CSCL  
10A

The evaluation focused on the following subjects: (1) the relative merits of alternative solar cell materials, based on performance and availability, (2) the best manufacturing methods for various solar cell options and the effects of extremely large production volumes on their ultimate costs and operational characteristics, (3) the areas of uncertainty in achieving large solar cell production volumes, (4) the effects of concentration ratios on solar array mass and system performance, (5) the factors influencing solar cell life in the radiation environment during transport to and in geosynchronous orbit, and (6) the merits of conducting solar cell manufacturing operations in space. Author

A77-51532 Space solar power versus space communica-  
tions. S. K. Sarkar (Swiss PTT, Berne, Switzerland). *International Astronautical Federation, International Astronautical Congress, 28th, Prague, Czechoslovakia, Sept. 25-Oct. 1, 1977, Paper 77-65*, 8 p. 8 refs.

Since a space solar power station will occupy the same geostationary orbit as communications satellites and will also use the RF spectrum for transmission there must be a tradeoff between the two types of spacecraft in terms of resource allocation of orbit and spectrum. This paper briefly reviews design, operating and cost factors for both types of space system and emphasizes resource constraints and comparative benefits. The solar power station concept is criticized as being cost-ineffective. B.J.

SOLAR SATELLITES: SPACE KEY TO OUR POWER FUTURE.  
G.R. Woodcock.  
Astronautics & Aeronautics, v.15, no.7/8,  
July/Aug.1977, p.30-43.

N77-33800\*# National Aeronautics and Space Administration  
Lyndon B. Johnson Space Center, Houston, Tex.  
SOLAR POWER SATELLITE. CONCEPT EVALUATION.  
ACTIVITIES REPORT. VOLUME 2: DETAILED REPORT  
Progress Report, Jul. 1976 - Jun. 1977  
Jun. 1977 1166 p refs  
(NASA-TM-74942; JSC-12973-Vol 2) Avail: NTIS  
HC A99/MF A01 CSCL 10A

Comparative data are presented among various design approaches to thermal engine and photovoltaic SPS (Solar Power System) concepts, to provide criteria for selecting the most promising systems for more detailed definition. The major areas of the SPS system to be examined include solar cells, microwave power transmission, transportation, structure, rectenna, energy payback, resources, and environmental issues. Author

N78-21611\*# National Aeronautics and Space Administration,  
Washington, D. C.  
SPACE SOLAR POWER. DESCRIPTION OF CONCEPT.  
RESULTS OF PRELIMINARY STUDIES, REQUIREMENTS  
FOR EVALUATION  
30 Mar. 1977 21 p  
(NASA-TM-79438) Avail: NTIS HC A02/MF A01 CSCL 10A

The nation is actively pursuing alternate sources of energy because of the problems or concerns related to obtaining required energy for the future from oil, gas, nuclear, and coal sources. Solar energy is an obvious candidate for consideration. Its use in the past has been limited by the relative cost of collecting and converting solar energy into electrical power. The increasing costs of other energy sources will make solar energy more attractive. During recent years a new concept for the collection of solar energy has been developed. This concept involves the location of solar power stations in space. The concept, results of preliminary studies, and requirements for space evaluation of such a project are discussed. Author

A79-15898 Solar power satellites revisited. J. E. Drummond (Power Conversion Technology, Inc., San Diego, Calif.). In: *Energy technology V: Challenges to technology. Proceedings of the Fifth Conference, Washington, D.C., February 27-March 1, 1978*. (A79-15879 04-44) Washington, D.C., Government Institutes, Inc., 1978, p. 487-498. 32 refs.

In the present paper, it is argued that a system of low-orbit solar power satellites could be much more cost effective than a system of geostationary solar power satellites. The parameters of this modified system are examined and found to be both necessary and sufficient for an economical utilization of solar power. Since the orbits of the satellites are chosen to be sun-synchronous, the system is termed the Insolation Power System (meaning constant sunlight power system). This IPS modification of the satellite power station appears to be technologically viable and economically attractive. V.P.

A79-34028 The construction of satellite solar power stations from nonterrestrial materials - Feasibility and economics. B. O'Leary (Princeton University, Princeton, N.J.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3*. (A79-34022 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1155-1167. 23 refs.

Studies have indicated that satellite power stations manufactured from nonterrestrial material in space could alleviate the global energy crisis as early as the 1990s. Costs could be competitive with fossil fuel and nuclear power and an environmentally acceptable and inexhaustible supply of base-load electricity could be provided anywhere on earth. An Apollo-scale program, using the Shuttle for earth-to-orbit transportation, is all that would be required to begin a cost-effective program of satellite power station construction. B.J.

Spaceflight, v. 19, no. 3  
p. 82-89

Mar.  
1977

## POWERSAT: AN ASTRONAUTICAL ENERGY SOLUTION

TL AAS Annual Meeting, 22d, Washington, 1976.  
787 Bicentennial space symposium ... cl977.  
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A2 Astronautical Society. III. American  
v. 35 Institution of Aeronautics and Astro-  
RR nautics. IV. Smithsonian Institution.  
National Air and Space Museum. V.  
Title. VI. Series.

Prospects for Satellite Power Stations (AAS76-05d)  
Robert A. Summers p. 209

N77-18442\* National Aeronautics and Space Administration.  
Lyndon B. Johnson Space Center, Houston, Tex.  
INITIAL TECHNICAL ENVIRONMENTAL AND ECONOMIC  
EVALUATION OF SPACE SOLAR POWER CONCEPTS.  
VOLUME 1: SUMMARY  
31 Aug. 1976 129 p  
(NASA-TM-X-74309: JSC-11568-Vol-1) Avail: NTIS  
HC A07/MF A01 CSCL 10A  
The research concerning the use of large solar power satellites  
in geosynchronous orbit to beam energy to collection stations  
on earth is summarized. F.O.S.

N77-18443\* National Aeronautics and Space Administration.  
Lyndon B. Johnson Space Center, Houston, Tex.  
INITIAL TECHNICAL ENVIRONMENTAL AND ECONOMIC  
EVALUATION OF SPACE SOLAR POWER CONCEPTS.  
VOLUME 2: DETAILED REPORT  
31 Aug. 1976 908 p  
(NASA-TM-X-74310: JSC-11568-Vol-2) Avail: NTIS  
HC A09/MF A01 CSCL 10A

The SPS concepts which appear to be technically feasible  
are discussed in terms of the economic viability and competitive  
costs with other energy sources. The concepts discussed include:  
power stations, microwave reception and conversion, space  
construction and maintenance, space transportation, and program  
costs and analysis. The conclusions presented include: (1) The  
maximum output of an individual microwave transmission link  
to earth is about 5 GW. (2) The mass of 10 GW SPS is between  
47,000,000 and 124,000,000 kg. (3) The silicon solar cell arrays  
make up well over half the weight and cost of the satellite. (4)  
The SPS in equatorial orbit will be eclipsed by the earth and by  
other satellites. F.O.S.

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1976  
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International and U.S. programs, solar flux :  
joint conference, American Section, Inter-  
national Solar Energy Society and Solar En-  
ergy Society of Canada, inc., August 15-20,  
1976, Winnipeg / editor, K. W. Boer. -- Cape  
Canaveral, Fla. : American Section of the  
International Solar Energy Society, cl976.  
x, 398 p. : ill. ; 28 cm. -- (Sharing the  
sun : v. 1)

## THE STATUS OF SATELLITE SOLAR POWER DEVELOPMENT

P. E. Glaser

CN-150,345, Administrative Report 1976  
ADMINISTRATIVE REPORT. 1776 BICENTENNIAL 1976  
NASA-ASEE SUMMER FACULTY FELLOWSHIP PROGRAM  
RESEARCH. (Prepared for NASA HQ, Office of  
Univ. Affairs). Aug. 1976.

Dr. John Ballard  
Assistant Professor  
Dept of Ind & Sys Engr  
University of Nebraska

Operations Research  
Investigations of Satellite  
Power Stations

pg I

Research - ASEE  
Research - NASA  
Education

N77-18488\* National Aeronautics and Space Administration.  
Marshall Space Flight Center, Huntsville, Ala.  
SATELLITE POWER SYSTEM: ENGINEERING AND  
ECONOMIC ANALYSIS SUMMARY  
Nov. 1976 282 p refs  
(NASA-TM-X-73344) Avail: NTIS HC A13/MF A01 CSCL  
10A

A system engineering and economic analysis was conducted  
to establish typical reference baselines for the photovoltaic, solar  
thermal, and nuclear satellite power systems. Tentative conclusions  
indicate that feasibility and economic viability are characteristic  
of the Satellite Power System. Anticipated technology related  
to manufacturing, construction, and maintenance operations is  
described. Fuel consumption, environmental effects, and orbital  
transfer are investigated. Space shuttles, local space transporta-  
tion, and the heavy lift launch vehicle required are also dis-  
cussed. Author

CR-150,346, Administrative Report 1976  
ADMINISTRATIVE REPORT. 1776 BICENTENNIAL 1976  
NASA-ASEE SUMMER FACULTY FELLOWSHIP PROGRAM  
RESEARCH. (Prepared for NASA HQ, Office of  
Univ. Affairs). Aug. 1976.

Dr. John Sellers  
Associate Professor of Biology  
Tuskegee University

Comparison of Various Absorbers  
for Solar Space Power Systems

pg 21

Research - ASEE  
Research - NASA  
Education

N79-23483\*# Boeing Aerospace Co., Seattle, Wash.  
SYSTEMS DEFINITION SPACE-BASED POWER CONVER-  
SION SYSTEMS Final Report, 8 Jun. 1975 - 30 Nov. 1976

30 Nov. 1976 95 p refs Prepared in cooperation with Garrett  
Corp., Los Angeles, and Thermo Electron Corp.  
(Contract NAS8-31628)  
(NASA-CR-150268. D180 20309-2) Avail: NTIS  
HC A05/MF A01 CSCL 10B

Potential space-located systems for the generation of electrical  
power for use on Earth are discussed and include: (1) systems  
producing electrical power from solar energy; (2) systems  
producing electrical power from nuclear reactors; and (3) systems  
for augmenting ground-based solar power plants by orbital sunlight  
reflectors. Systems (1) and (2) would utilize a microwave beam  
system to transmit their output to Earth. Configurations implemen-  
ting these concepts were developed through an optimization  
process intended to yield the lowest cost for each. A complete  
program was developed for each concept, identifying required  
production rates, quantities of launches, required facilities, etc.  
Each program was costed in order to provide the electric power  
cost appropriate to each concept.

A R H

N77-21136\*# National Aeronautics and Space Administration,  
Lyndon B. Johnson Space Center, Houston, Tex.  
SOLAR POWER SATELLITE: ANALYSIS OF ALTERNATIVES  
FOR TRANSPORTING MATERIAL TO GEOSYNCHRONOUS  
ORBIT  
William J. Graff and C. J. Huang 1976 265 p refs Prepared  
in cooperation with Houston Univ.  
(Grant NGT-44-005-114)  
(NASA-TM-X-74680) Avail: NTIS HC A12/MF A01 CSCL  
22A

A systems design study of the alternative methods and relative  
merits of various approaches to transporting and assembling a  
solar power satellite in geosynchronous orbit was conducted.  
State of the art alternatives for chemical and electrical interorbital  
propulsion were studied, and several possible scenarios for  
construction were proposed. Author

## SOLAR - OTHER UTILIZATION

79A51737 ISSUE 23 PAGE 4366 CATEGORY 44  
79/00/00 6 PAGES UNCLASSIFIED DOCUMENT

**UTTL:** Economic and performance comparisons of salty and saltless solar ponds

**AUTH:** A/EDESESS, M.; B/BENSON, D.; C/HENDERSON, J.; D/JAYADEV, T. S. PAA: D/(Solar Energy Research Institute, Golden, Colo.)

In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979. Proceedings, Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 56-61.

**MAJS:** /\*ECONOMIC ANALYSIS/\*ENERGY CONVERSION EFFICIENCY/\*SALINITY/\*SOLAR PONDS (HEAT STORAGE)/\*SYSTEMS ENGINEERING/\*WATER HEATING

**MINS:** / CLEAN ENERGY/ ENERGY TECHNOLOGY/ LOW COST/ OPTIMIZATION/ PERFORMANCE PREDICTION/ SODIUM CHLORIDES / TEMPERATURE PROFILES

**ABA:** (Author)

**ABS:** The optimum solar pond design is site-dependent and application-dependent. Foremost of the design decisions is the choice of a salty (nonconvecting) pond or a saltless (convecting) pond. The decision variables are: local availability and cost of salt, type of salt available and its properties, and possible environmental factors such as the effects of salt runoff and the existence of ground water. The availability of salt is an important factor in determining the economics of salty ponds. For example, sodium sulfate is a potentially low-cost substitute for sodium chloride, and is expected to be in plentiful and widely distributed supply in the near future as a waste product of flue gas desulfurization at coal-fired utility plants. This paper discusses the potential supply of such salts and estimates the break point in net cost of salt at which a convecting pond becomes economically competitive with the salty pond.

79A51734 ISSUE 23 PAGE 4366 CATEGORY 44  
79/00/00 4 PAGES UNCLASSIFIED DOCUMENT

**UTTL:** Solar pond concepts - Old and new

**AUTH:** A/JAYADEV, T. S.; B/EDESESS, M.; C/HENDERSON, J. PAA: C/(Solar Energy Research Institute, Golden, Colo.)

In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979. Proceedings, Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 45-48.

**MAJS:** /\*HEAT STORAGE/\*MOLTEN SALTS/\*SOLAR COLLECTORS/\*SOLAR PONDS (HEAT STORAGE)/\*WATER HEATING

**MINS:** / CONVECTIVE FLOW/ ENERGY TECHNOLOGY/ MATHEMATICAL MODELS/ PERFORMANCE PREDICTION/ RESERVOIRS/ SOLAR HEATING/ TECHNOLOGY ASSESSMENT/ THERMOCLINES

**ABA:** B.J.

**ABS:** It is shown that the salty nonconvecting pond is a viable and economical way of collecting and storing large quantities of solar energy, especially where salt is free or inexpensive. Other techniques may be more desirable where salt is not so readily available. Combinations of collectors with pond storage are appropriate for some applications and can provide water of higher temperature, but they enter the realm of higher and more expensive technology. Where salt is not free or not inexpensive the deep convecting pond may be an economically viable and environmentally acceptable alternative and deserves further investigation.

79N78496 CATEGORY 44 79/00/00 140 PAGES  
UNCLASSIFIED DOCUMENT

**UTTL:** Physics of the solar pond TISR: Ph.D. Thesis

**AUTH:** A/HULL, J. R.

**CORP:** Iowa State Univ. of Science and Technology, Ames.

**SAP:** Avail: Univ. Microfilms Order No. 7916200

**MAJS:** /\*ENERGY CONVERSION/\*SOLAR PONDS (HEAT STORAGE)/\*THERMOCHEMISTRY

**MINS:** / IOWA/ MATHEMATICAL MODELS/ OPTICAL PROPERTIES/ SALTS / THERMODYNAMIC PROPERTIES



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BOA11343 ISSUE 1 PAGE 80 CATEGORY 44 79/00/00  
2 PAGES UNCLASSIFIED DOCUMENT

UTTL: A cheap method of improving the performance of roof type solar stills

AUTH: A/AKINSELE, V. A.; B/DURU, C. U. PAA: B/(Lagos, University, Lagos, Nigeria)

Solar Energy, vol. 23, no. 3, 1979, p. 271, 272.

MAJS: /\*DESALINIZATION/\*DISTILLATION EQUIPMENT/\*ENERGY TECHNOLOGY/\*SOLAR ENERGY/\*STILLS/\*WATER TREATMENT

MINS: / CHARCOAL/ NIGERIA/ PERFORMANCE TESTS/ SOLAR HOUSES

ABA: M.E.P.

ABS: The paper presents the results of a test comparing the performance of two types of roof type solar stills. It is reported that the use of charcoal to line the basin of a typical still results in improved productivity. The charcoal is used to reduce the thermal inertia of the still, which is possible for the following reasons: (1) charcoal exhibits capillary action and is hence capable of maintaining a wetted surface whenever it is partially immersed in a liquid; (2) charcoal absorbs incident radiation, and (3) the rough surface scatters rather than reflects incident radiation which reduces reflected losses. In conclusion it is noted that the production rate is increased the most in the morning and on cloudy days when values of direct radiation are low.

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1979

Intersociety Energy Conversion Engineering Conference, 14th, Boston, 1979.  
Proceedings of the 14th Intersociety Energy Conversion Engineering Conference, Boston, Massachusetts, August 5-10, 1979.  
-- Washington, D. C. ; American Chemical Society, c1979.

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## THE STEADY STATE SALT GRADIENT SOLAR POND. C. F. KOOL.

Solar Energy, vol 23, no 1, 1979, p. 37-45.

**Abstract**—The three-zone salt gradient solar pond is analyzed as a steady-state flat-plate solar energy collector. The resultant efficiency equation is of the Hottel-Whillier-Bliss type commonly used for flat-plate collectors. The quantities that occur in this equation—the effective absorptivity-transmissivity product  $\alpha\tau$ , the loss factor  $U_L$ , the heat removal factor  $F_R$ , and the incident angle modifier  $\theta(i)$ —are related to the physical properties and dimensions of the pond. For a given  $\Delta T/H$  [(fluid inlet temperature—surface temperature)/insolation], the thickness of the nonconvective zone can be adjusted for maximum efficiency.  $U_L$  and  $\alpha\tau$  are smaller than the equivalent quantities for flat-plate collectors, while  $\theta(i)$  and  $F_R$  are close to unity. As a consequence, steady-state salt gradient solar ponds are less efficient than common flat-plate collectors at low  $\Delta T/H$ , but they are more efficient at high  $\Delta T/H$ .

ADVENTURES IN ALTERNATE ENERGY DAVID M. BISSEGER,  
SOLAR GREENHOUSE, by Edward Moran.  
Popular Science, vol. 214, no. 4, April 1979, p.50-52.

This compact, easy-to-build attached solar greenhouse, located in Phoenix, Ariz., provides an ideal space for growing vegetables in winter without using any auxiliary power for heat. Likewise, in summer, no exhaust fans are required to prevent overheating. Dave Bissegger designed and built the structure for just \$275, including \$85 for the cost of the solar components.

**N80-10663#** Midwest Research Inst., Golden, Colo  
**SOLAR POND CONCEPTS: OLD AND NEW**  
T. S. Javacev, Michael Edesess, and Jon Henderson 1979 7 p  
refs. Presented at the 14th Intersoc. Energy Conversion Eng  
Conf., Boston, 5-10 Aug 1979  
(Contract EG-77-C-01-4042)  
(SERI/TP-35-208. Conf-790803-3) Avail NTIS  
HC A02/MF A01

Different types of solar ponds were considered from the early 1900s to the present. Salty ponds use salt to create a nonconvecting pond. Shallow solar ponds were investigated by Shuman and Willsie in 1906 and 1907 and are currently being studied by Lawrence Livermore Laboratories. Swedish investigators are studying a combination of solar collectors and water

storage in a pond-cover configuration. In addition, there are thermoclines created in large bodies of water, as in large reservoirs. The various types of solar ponds are surveyed and the best of the ideas are combined to synthesize new concepts. A new solar pond concept is presented which combines the good features of convecting and nonconvecting (salty) ponds. DOE

THERMAL ANALYSIS IN THE FOCAL SPOT OF A SOLAR FURNACE. Enrico Lorenzini and Marco Spiga.

Solar Energy, Vol 22, no. 6, 1979 p. 515-520

**Abstract**—The paper deals with the analytical determination of the temperature distribution in a sample placed in the focal plane of the paraboloidal mirror of a solar furnace. Several different heat pulses are considered and some graphs are shown.

79A39010# ISSUE 16 PAGE 2930 CATEGORY 5 RPT#:  
AIAA PAPER 79-1264 79/06/00 6 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Project Sunrise --- solar-powered aircraft flight demonstration  
AUTH: A/BOUCHER, R. J. PAB: A/(Astro Flight, Inc., Venice, Calif.)  
AIAA, SAE, and ASME, Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18-20, 1979. AIAA 6 p.  
AFPA-USAFA-sponsored research.  
MAUS: /AIRCRAFT CONFIGURATIONS/AIRCRAFT DESIGN/FLIGHT TESTS/SOLAR ELECTRIC PROPULSION  
MINS: /ELECTRIC MOTORS/GRAPHS (CHARTS)/INSOLATION/PHOTOVOLTAIC CELLS/PROTOTYPES/TECHNOLOGY UTILIZATION  
ABA: S. G.  
ABS: The solar-powered aircraft Sunrise is described, with special emphasis on the flight demonstration program, design features of the Sunrise air vehicle, aerodynamic configuration, airframe, solar power subsystem, propulsion subsystem, and flight envelope. Calculated and measured performance are given. The Sunrise Program demonstrated the feasibility of solar-powered flight, ways of harnessing the unique behavior and attributes of these solar-powered vehicles are now being explored.

**A79-49183 #** Calculation of the optical characteristics of high-power two-mirror solar furnaces (Raschet opticheskikh kharakteristik dvukhzerkal'nykh solnechnykh pechei bol'shoi moshchnosti). S. A. Azimov, Kh. M. Mallaeva, I. I. Pirmatov, T. T. Riskiev, and S. Kh. Suleimanov (Akademiya Nauk Uzbekskoi SSR, Fiziko-Tekhnicheskii Institut, Tashkent, Uzbek SSR). *Geliotekhnika*, no. 2, 1979, p. 23-28, 9 refs. In Russian.

A method of designing large solar furnaces is proposed. For illustration, the method is applied to the design of a two-mirror solar furnace and a tower-mounted solar plant. V.P.

Solar boilers get hot. Robert B. Aronson.

Machine Design. v. 51, no. 16, July 1979, p. 20-25.

Power plants in America's southwest may one day be characterized by acres of mirrors that focus the sun's rays on massive collector towers. The technology is available, the hardware has been tested, and by 1990 the first prototype plant should be operating.



TK  
2896  
.155  
1979  
Intersociety Energy Conversion Engineering  
Conference, 14th, Boston, 1979.  
Proceedings of the 14th Intersociety  
Energy Conversion Engineering Conference,  
Boston, Massachusetts, August 5-10, 1979.  
— Washington, D. C. : American Chemical  
Society, c1979.

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# UNDER GROUND THERMAL STORAGE IN THE OPERATION OF SOLAR PONDS.

A. Akbarzadeh and G. Ahmadi

Energy, vol. 4, no. 6, Dec. 1979, pp. 1119-1125.

Abstract—The thermal interaction between a large solar pond and the surrounding ground is considered. For a given sinusoidal variation of the temperature at the bottom of the pond, the time-dependent temperature profiles in the ground are calculated and the corresponding heat fluxes to or from the ground as functions of time are obtained. The temperature variations in the ground for several years are plotted and the heat transfer between the solar pond and the ground thermal storage is discussed. The efficiency of the heat recovery is studied and its significance is pointed out.

## SUN ON THE WINGS.

Aerospace, vol 6, no 7, August/September, 1979  
p. 26.

Icarus made the fatal mistake of flying too close to the sun, but Fred To and David Williams depend on the sun to get their most unusual aircraft off the ground.

79N77276# CATEGORY 41 RPT#: NTIS/PS-79/0033/5  
NTIS/PS-78/0002 79/02/00 100 PAGES UNCLASSIFIED  
DOCUMENT

Supercedes NTIS/PS-78/0002

UTFL: Solar distillation. Citations from the Engineering  
Index data base. TLSP: Progress Report. 1970 - Dec.  
1978

AUTH: A/HUNDEMANN, A. S.  
CORP: National Technical Information Service, Springfield,  
Va. AVAIL: NTIS SAP: HC \$28.00/MF \$28.00

NOTE: /\*BIBLIOGRAPHIES/\*DISTILLATION/\*SOLAR COLLECTORS  
MINS: / ABSTRACTS/ DESALINIZATION/ DESIGN ANALYSIS/  
FEASIBILITY/ WATER

N90-15587# Argonne National Lab., Ill. Components Technology  
Div

## STABILITY CONSIDERATIONS AND A DOUBLE-DIFFUSIVE CONVECTION MODEL FOR SOLAR PONDS

E. I. H. Lin, W. T. Sha, and S. L. Soo Apr. 1979 42 p refs  
Prepared jointly with Illinois Univ., Urbana.

(Contract W-31-109-eng-38)

(ANL-CT-79-34) Avail: NTIS HC A03/MF A01

A brief survey is made on the basic principles, current designs and economic advantages of salinity gradient solar ponds as solar collectors and reservoirs. Attention is focused on the subject of stability, and pertinent existing results are summarized and discussed. Details of the derivation of three-dimensional stability criteria for thermohaline convection with linear gradients are presented. Ten key questions pertaining to stability are posed, whose answers must be sought through extensive analytical and numerical studies. Possible methods of approach toward enhancing solar-pond stability are also discussed. For the numerical studies of pond behavior and stability characteristics, a double-diffusive convection model is proposed. The model can be constructed by extending the three-dimensional thermohydrodynamic computer code COMMIX SA, following the necessary steps outlined; computational plans are described.

DOE

DETERMINING THE THERMAL LOSSES TO THE ATMOSPHERE  
FROM A SOLAR STILL

G. N. Bobrovnikov, B. M. Achilov, O. S. Kamilov,  
S. Kakharov and A. Odinaev

Applied Solar Energy, vol. 15, no. 4, 1979, pp. 66-

68.

A method is given for calculating and determining thermal losses through the transparent insulation, bottom, and side walls. The calculations were carried with the aid of a NAIRI-2 computer for a broad range of initial-data numerical values in order to study the way in which various parameters affect the intensity of heat exchange between the transparent insulation and the environment.

N80-16570# New Mexico Energy Inst., Las Cruces.  
SOLAR POWERED AGRICULTURAL IRRIGATION PUMPING  
Final Report. 1 Jun. 1976 - 28 Feb. 1979  
G. H. Abernathy and T. R. Mancini 15 Feb 1979 31 p refs  
(PB-299294/9; NMEI-31) Avail: NTIS HC A03/MF A01 CSCL  
02C

A solar-powered irrigation pumping system was designed and installed at Willard, New Mexico. The system incorporated an east-west oriented field of parabolic trough solar collectors to heat oil. The hot oil in turn heated freon which drove a high speed turbine connected to the irrigation pump. In conjunction with the solar pump, agricultural experiments were conducted. These included drip irrigation of typical food crops that could be grown in the area. GRA

CALCULATION OF THE OPTICAL CHARACTERISTICS OF HIGH-  
POWER TWO-MIRROR SOLAR FURNACES

S. A. Azimov, Kh. M. Mallaeva, I. I. Primatov, T. T.  
Rishiev and S. Kh. Suleimanov

Applied Solar Energy, vol. 15, no. 2, 1979, pp. 23-

24.

A calculation scheme for large solar furnaces is considered. The results can be used in designing large solar furnaces and solar electric power plants of tower type.

SOLAR PROCESS AND MAKE-UP AIR HEATING.

Building System Design, vol 76, no 4, June/July 1979,  
p. 23-32.

N79-32680# Mound Lab., Miamisburg, Ohio.  
EVALUATION OF A LARGE NONCONVECTIVE SOLAR  
POND

Layton J. Wittenberg and Marc J. Harris 1979 12 p refs  
Presented at the Solar Energy Storage Options Workshop, San  
Antonio, 18 Mar. 1979

(Contract EY-78-C-04-0053)

(MLM-2606(OP); Conf-790328-2) Avail: NTIS HC A02/MF A01

The operational performance of one of the largest functional, salt-gradient solar ponds in the world is evaluated. This solar pond was constructed by the City of Miamisburg on property adjacent to the Mound Facility. Data are collected on the annual thermal cycle characteristics of this combined solar energy collector and thermal storage system, and system performance is evaluated based upon models developed at several university research ponds. DOE

N80-14546# Midwest Research Inst., Golden, Colo.  
THERMAL ENERGY STORAGE FOR SOLAR APPLICATIONS:  
AN OVERVIEW

Charles Wyman Mar. 1979 123 p refs

(Contract EG-77-C-01-4042)

(SERI/TP-34-089) Avail: NTIS HC A06/MF A01

The economic role of storage for solar home heating and stand-alone electric plants are examined. Factors which affect the economics of storage are discussed. The costs and storage capacities of representative sensible and latent heat storage materials are summarized. Various modes of operation are also presented for thermal storage by reversible chemical reactions. Containers and heat exchangers are reviewed to illustrate possible approaches to reducing storage costs. Reversible reaction storage, and gas-solid reactions are shown to have desirable attributes for solar energy storage. DOE

N80-16568# Economics, Statistics and Cooperatives Service,  
Washington, D. C. National Economics Div.

SOLAR ENERGY FOR AGRICULTURE: REVIEW OF  
RESEARCH Final Report

W. K. Trotter, W. G. Heid, Jr., and R. G. McElroy Aug 1979  
29 p refs

(PB-298688/3; ESCS-67) Avail: NTIS HC A03/MF A01 CSCL  
02B

Solar energy use in various agricultural applications is summarized. Grain drying, heating and cooling of greenhouses and rural residences, heating livestock shelters, drying crops other than grain, food processing, and irrigation are discussed. An exploratory economic assessment of solar energy technologies is given. GRA

FIRST SOLAR-POWERED MANNED FLIGHT.

Aircraft Engineering, vol 51, no 10, October 1979,  
p. 15-16.

## SOLAR-POWERED AIRCRAFT TAKE TO THE AIR.

Flight International, vol 115, no 3662, p. 1721., 26 May 1979.

## UK'S FIRST SOLAR AIRCRAFT TAKES OFF.

Flight International, vol 115, no 3667, June 30, 1979, p. 2336.

also picture p. 2351.

## Solar Powered Irrigation

by F.G. Dawson, G. Alexander & P.L. Hofmann

Sunworld, Vol. 3, No. 5, 1979, p. 122-125

The technology is here, but the price is still high.

## SOLAR SEWAGE TREATMENT-LOW-TECH SYSTEM HARNESSES NATURAL PROCESSES.

Frank Baylin.

Popular Science, vol 214, no 5, May 1979, p. 106-107.

## Low-Cost Pool Heater

by R. Swindell

Sunworld, Vol. 3, No. 5, 1979, p. 132-135

## Do-it-yourself: a trickling water pool heater.

A79-50344 Concentration of a cassegrain solar furnace. M. H. Cobble, W. C. Hull, and E. F. Thacher (New Mexico State University, Las Cruces, N. Mex.). In: Learning to use our environment; Proceedings of the Twenty-fifth Annual Technical Meeting, Seattle, Wash., April 30-May 2, 1979. (A79-50326 22-42) Mount Prospect, Ill., Institute of Environmental Sciences, 1979, p. 183-187.

A solar furnace consisting of a paraboloid of revolution that tracks the sun, and a hyperboloid of revolution that has a focus in common with the paraboloid is analyzed for the concentration of a nonuniform sun, the concentration of a uniform sun, and the concentration with mirror error. The theoretical results are compared with experimental results for a specific cassegrain solar furnace.

(Author)

## SOLAR WATER PUMPING, by Mehdi N. Bahadori.

Solar Energy, vol. 21, no. 4, 1978, p. 307-316.

The principles of solar water pumping are briefly described. The mechanical energy needed for pumping water may be produced by thermodynamic, or direct-conversion methods. In thermodynamic conversion a fluid with high internal energy is produced in solar collectors or concentrators. The internal energy of the fluid may be utilized in Rankine, Brayton, or Stirling cycles or in specially designed devices. The nature of irrigation in the arid regions calls for scattered water pumping stations, hence small solar pumps. These pumps may be mass produced and delivered to the site. The direct conversion includes photovoltaic, thermoelectric and thermionic processes. With the current prices of solar cells photovoltaic water pumping seems to be economically competitive with the current solar Rankine-cycle system in the power ranges of below 5 kW, especially when both systems have to be imported by a developing country.

(Author)

## INDUSTRY WARMS UP TO SOLAR ENERGY USE.

Chem. Engineering, v.85, no.20, Sept.11,1978, p.114-16.

## A number of demonstration units will go onstream

this year to provide solar-fueled process heat

for miscellaneous industrial applications.

TK

Palz, Wolfgang

1056

Solar electricity : an economic

.P34

approach to solar energy / Wolfgang

Palz. London ; Boston : Butterworths, 1978.

xv, 292 p. : ill. ; 26 cm.

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Royal Society of London  
Philosophical Transactions,  
Ser.A, v.295, no.1414

Feb.7,  
1980

SOLAR ENERGY. (A discussion held Nov.15-16,1978.  
Organized by George Porter and William Hawthorne).  
SIR HERMANN BONDI, F.R.S.

Indirect utilization of solar energy P.501-506

Discussion: J. W. JEFFERY

The atmosphere can be regarded as a heat engine converting solar heat into the mechanical energy of wind, which in turn generates waves on the surface of the sea, so that both wind and wave energy can readily be traced back to the solar input.

Wind energy used to be a major source of power, but gave way to the much cheaper and more reliable source presented by coal. Looking to the future, we can certainly make much better windmills (15% efficiency was perhaps the best in the past) but the improvement in size/cost ratio with increasing size drives one to large structures. A preference for disaggregated supply is needed to put even medium sized aerogenerators into the running, and a house-by-house supply would require quite sizeable structures. Really big structures, especially on the favoured hill top sites, would raise environmental questions that might drive one to off-shore locations, though of course these may well involve increased costs. Vertical axis as well as horizontal axis machines are being studied. Isolated locations, where the competition is less severe, might offer the first chance of economic viability without going to very large sizes.

Wave energy has the great merit of being dependent on a non-local supply. In particular, the longer waves with their high energy content may originate hundreds or even thousands of miles from the scene of exploitation, and so the system has a steadiness much greater than might be expected. Indeed, the U.K. is located in one of the World's most favourable positions.

Engineering exploitation is made difficult by the need for the apparatus to survive the wildest conditions and by the fact that, in many devices, the input is a large force with small displacement, a form of power for which there is little practical experience in its utilization. A variety of devices are being supported so as to establish where we should concentrate our effort. The potential size of the resource and its seasonal phasing in line with demand make this a most essential field of renewable development.

SAUDI ARABIA LOOKS AT THE SUN.

A. A. M. Sayigh

Sunworld, Vol. 2, No. 2, May 1978, p. 46-49.

SOLAR ENERGY INSTALLATIONS FOR PUMPING IRRIGATION  
WATER, by J. T. Pytlinski.

Solar Energy, vol. 21, no. 4, 1978, p. 255-262.

Solar radiation reaching the surface of the earth is intermittent due to atmospheric conditions and the rotation of the earth. This intermittence and variability inherently limit the useful conversion of solar radiation by requiring either intermediate storage of energy or application to a task where intermittency is acceptable.

The pumping of irrigation water is an operation where normally intermittent operation may be acceptable. This fact, plus the potential economical benefits to be obtained, has instigated the research in this area. And since this problem is basically that of converting solar radiation to mechanical energy, it is very much related to past efforts to develop "solar engines" which might be used for a number of purposes, e.g. to power irrigation systems.

Various historical surveys of solar energy experiments have been published [1-3]; not any one of them, however, has been purposely addressed to the subject of past developments of solar powered irrigation systems. Therefore, the objective of this paper is to present an overall picture of the past efforts which have lead to the present progress in this field.

WARMING CANS DOWN UNDER.

R. N. Morse

Sunworld, Vol. 2, No. 2, May 1978, p. 38 & 39.

**Solar energy saves  
fuel in a soft-drink  
factory.**

SOLAR-POWERED CROP SPRAYER, by R. Wijewardene.

Sunworld, vol. 2, no. 3, August 1978, p.62-3.



TJ  
810 International Symposium-Workshop on Solar  
Energy, Cairo, 1978.

.173 International Symposium-Workshop on  
1978 Solar Energy : [symposium lectures], 16-  
22 June 1978, Cairo, Egypt / presented by  
Clean Energy Research Institute, University  
of Miami, Florida ; sponsored by National  
Science Foundation ; edited by T. Nejat  
Veziroglu, Homer W. Hiser. -- [s.l.:s.n.,

USE OF SATELLITES IN SOLAR APPLICATIONS P375  
H. W. Hiser, University of Miami, Coral Gables, Florida, U.S.A.

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Saudi Arabia

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A. A. M. Sayigh, University of Riyadh, Riyadh, Saudi Arabia

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T. Khalil, University of Miami, Coral Gables, Florida, U.S.A.

A80-11343 A cheap method of improving the perfor-  
mance of roof type solar stills. V. A. Akinsete and C. U. Duru  
(Lagos, University, Lagos, Nigeria). Solar Energy, vol. 23, no. 3,  
1979, p. 271, 272.

The paper presents the results of a test comparing the  
performance of two types of roof type solar stills. It is reported that  
the use of charcoal to line the basin of a typical still results in  
improved productivity. The charcoal is used to reduce the thermal  
inertia of the still, which is possible for the following reasons: (1)  
charcoal exhibits capillary action and is hence capable of maintaining  
a wetted surface whenever it is partially immersed in a liquid; (2)  
charcoal absorbs incident radiation, and (3) the rough surface  
scatters rather than reflects incident radiation which reduces re-  
flected losses. In conclusion it is noted that the production rate is  
increased the most in the morning and on cloudy days when values  
of direct radiation are low.  
M.E.P.

LARGE-SCALE SOLAR DESALINATION IS STILL IN THE  
EXPERIMENTAL STAGE. M. Ali Kettani.

SunWorld, vol 3, no 3, 1979, p. 76-85.

*Review of Solar Desalination*

WASHING CANS OUT WEST.

Jorgen Vindum & Keith Bentz

Sunworld, Vol. 2, No. 2, May 1978, p. 35-37.

The US Department of Energy is  
sponsoring a number of programs to  
develop solar energy systems for indus-  
trial process hot water. In one of the  
most promising of these, Acurex Cor-  
poration is working with Campbell  
Soup Company and National Canners  
Association to test a solar industrial  
process hot water system at the Camp-  
bell Soup Plant in Sacramento, Cali-  
fornia.

JOSEPH ORR'S FABULOUS "MUD HEAT-STORAGE" SOLAR GREENHOUSE  
The Mother Earth News, no. 51, May/June 1978,  
p. 94-97.

DIRECT USE OF SOLAR ENERGY FOR WATER DESALINATION, by  
S.M.A. Moustafa and G.H. Brusewitz, Solar Energy, vol. 22  
no. 2, 1979, p.141-149.

Abstract—Solar energy utilization in three different types of solar desalination systems is considered. The overall  
efficiency of a typical basin type solar desalination plant is 30 per cent or lower. The major design factors affecting  
energy utilization are basin temperature, condensing surface temperature and ambient air temperature. Basic  
reflection and thermal radiation from the evaporating surface and transparent cover are the major sources of heat  
energy loss in a solar still. The efficiency of a solar desalination plant can be improved by controlling radiation from  
the plant basin and by the reuse of the latent heat of condensation.

# SOLAR AND WIND ENERGY APPLICATIONS IN HAWAII, by George T. Koide, and Patrick K. Takahashi.

Solar Energy, vol. 21, no. 4, 1978, p. 297-305.

**Abstract**—The study on solar radiation and wind power applications is a facet of the total State of Hawaii solar assessment program. Engineering consultants, governmental authorities from the Department of Energy, State of Hawaii, and counties, technology assessment specialists, and businessmen were contacted for input into this paper. The resultant late 1977 survey is a broad implementation plan highlighting seven typical applications—three solar, three wind and one combination.

It was not the intention of this study to produce refined engineering/economic analyses. However a principal objective was to stimulate the development of solar energy by assisting in the first crucial steps of the planning process.

This investigation selected projects which had potential for immediate implementation in the State of Hawaii. Variety in form of application, type of engineering analysis and location within the State was sought. To a large extent these basic premises were well met, as applications range from agriculture to aquaculture to tourism to education on three islands.

In varying degrees, each project is recommended either for further study or immediate implementation. Some of the economics may be dubious, as would be the situation in most original applications. However, with appropriate governmental aid or incentives, these pilot projects could serve to improve economy of scale, spur associated developments, and in the long run, improve Hawaii's balance of trade.

# SOLAR POND STABILITY EXPERIMENTS, by J. P. Leshuk, R. J. Zaworski and D. L. Styrus and O. K. Harling

Solar Energy, vol. 21, no. 3, 1978, p. 237-244

**Abstract**—Questions about the long term stability of salinity gradients necessary for the proper operation of nonconvecting salt pond solar collector/storage systems have been raised in earlier feasibility studies. A cooperative experimental effort was established between Battelle-Northwest Laboratories and Oregon State University to investigate some of these questions.

The results of a year long experimental study are reported with conclusions drawn to date from partial data reduction. Although severe modeling problems were encountered, generally encouraging observations about the stability of these thermo-haline systems were made. Maximum bottom temperatures of 76°C were obtained as a result of insolation levels below those occurring in field installations. Stable temperature gradients ranging from 150-300°C/m were observed. Slow top and bottom mixing layer growth was the only failure mode noted despite attempts to introduce instabilities at intermediate levels.

# SOLAR PONDS.

Samuel Walters.

Mech. Eng., v.100, no.1, Jan.1978, p.52-3.

The collection of solar energy on a large scale for power plants or major facilities magnifies the incompletely solved technical and economic problems of residential solar utilization systems. It has been suggested that large ponds of water, made with bulldozers, could be used to collect and store solar heat. The ponds would act much like conventional collectors.

# Solar Heating & Cooling, v.3, no.4, Aug.1978.

15	Students Cultivate Fish and Vegetables in Solar Greenhouse
18	Installation of Solar Furnace Cuts Utility Costs
20	Commercial Building Retrofit Completed in Connecticut
27	Custom Solar House Utilizes Hybrid Collectors
33	Prototype Retrofit Heats, Cools House and Pool
36	Retrofit Provides Solar-Heated Water for 400 Tenants

# ABSORPTION OF SOLAR RADIATION IN PONDS.

R. Viskanta & J. S. Toor

Solar Energy, Vol. 21, No. 1, 1978, p. 17-25.

The purpose of this paper is to develop realistic models for predicting solar radiation transfer in water and water with suspensions which could be used as design tools. The existing analyses [13, 14] are extended and generalized. Using the models developed, studies are conducted to determine the local absorption of solar radiation in solar ponds and the ocean to gain improved understanding of the phenomena. The effects of pond depth, bottom reflectance and meteorological conditions on the local deposition of solar radiation are determined. The influence of additives to the water such as suspensions and pigments and the effect of their distribution in solar ponds and ocean water on the absorption of solar radiation are investigated. Sample numerical results are presented graphically and discussed in the paper.

A79-33220 \* Design construction and short term performance of a solar pond. J. N. Gorasia, (Government Engineering College, Jubulpore, India), J. S. Saini, and C. P. Gupta (Roorkee University, Roorkee, India). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings, Volume A. (A79 33212 13-44) Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 110-118. 5 refs.

A78-19833 The circular cylindrical reflector - Application to a shallow solar pond electricity generating system. C. F. Kooi. Solar Energy, vol. 20, no. 1, 1978, p. 69-73. 12 refs.



Solar Heating & Cooling, v.3, no.3, June 1973.

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|----|---|
| 10 | Choosing a Pool Cover to Conserve Energy                              |
| 12 | Plumbing a Pool for a Solar Heating System                            |
| 21 | Solar Assisted Heat Pump Systems: An Analysis                         |
| 28 | Low Temperature Collectors for Pool Heating Applications              |
| 9  | Largest Pool System Yet Cuts Costs and Lengthens Season               |
| 16 | San Diego Success Prompts Sheraton to Solar Heat a Second Pool        |
| 18 | Unconventional Solar Collectors Heating Above-Ground Pool in Colorado |
| 33 | Dual Purpose System Heats Pool and Spa                                |
| 36 | Jersey Pool Season is Memorial Day through Labor Day                  |
| 44 | Awning Configuration Satisfies Siting Problems                        |

A78-48519 Principles and applications of solar energy. P. N. Cheremisinoff (New Jersey Institute of Technology, Newark, N.J.) and T. C. Regino (Pandullo Quirk Associates, New York, N.Y.). Ann Arbor, Mich., Ann Arbor Science Publishers, Inc., 1978. 254 p. 130 refs. \$15.

Historical aspects regarding the utilization of solar energy are considered along with questions concerning solar energy availability, thermal collection devices, thermal solar energy applications, the photovoltaic generation of electricity, energy from the wind, ocean thermal gradient power, chemical conversion of solar energy, and biological conversion of solar energy. Attention is given to nonconcentrating collectors of the flat plate type, liquid-cooled flat plate collectors, air-cooled flat-plate collectors, evacuated tube types of nonconcentrating collectors, concentrating collectors, the heating of buildings, air systems, hydronic systems, the cooling of buildings, domestic water heating, solar irrigation, thermal generation of electricity, the Smith-Putnam wind turbine, photoelectrolysis, electrochemical photovoltaic cells, hydrogen utilization, the production of photosynthetic biomass, solid and animal wastes as biomass, and the conversion of biomass to energy. G R

SOLAR DRYING IN PAPER BINS.  
Farm J., Mid-Feb.1978, p.H-2 - H-3.

ASSESSMENT OF SOLAR APPLICATIONS FOR TRANSFER OF TECHNOLOGY, A CASE OF SOLAR PUMP, by Jyoti K. Parikh  
Solar Energy, vol. 21, no. 2, p. 99-106

**Abstract**—For the large and increasing rural population in the developing countries, decentralized solar applications could be relevant. However, new solar technologies being developed in the laboratories presently have to ultimately be acceptable in the field conditions. The conditions which have to be satisfied before the solar applications could be acceptable are discussed. The solar pump is examined in detail in particular due to the interest expressed by many developing countries in this specific application. A comparative techno-economic analysis is carried out for solar pumps and diesel pumps which considered escalation of the diesel price and factors related to climate, geography, locale, social and institutional environment for two types of uses namely for drinking water and for irrigation. It seems unlikely that a solar pump could compete with the diesel engine before the costs are brought down by a factor of 20-50 for irrigation purposes. However, for obtaining the drinking water the cost reduction required is by a factor less than 10 than currently charged for the prototypes. Although specific example of India is taken the matters are relevant to most developing countries. The issues discussed for the case of a solar pump are also relevant to other solar applications used only for seasonal purposes since the capital costs are high and operating diesel pumps during the season would be cheaper for several decades.

Solar Heating & Cooling, v.3, no.3, June 1978.

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|----|---|
| 10 | Choosing a Pool Cover to Conserve Energy                              |
| 12 | Plumbing a Pool for a Solar Heating System                            |
| 21 | Solar Assisted Heat Pump Systems: An Analysis                         |
| 28 | Low Temperature Collectors for Pool Heating Applications              |
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| 16 | San Diego Success Prompts Sheraton to Solar Heat a Second Pool        |
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OF POOR QUALITY

**TU**  
**163.2**  
**.G74**  
**1978**

**Greater Los Angeles Area Energy Symposium, Los Angeles, 1978.**

**Greater Los Angeles Area Energy Symposium**

• Solar Energy for Process Heat Applications: Priority Actions to Stimulate Use in California — Rosalyn H. Barbieri, Jet Propulsion Laboratory

A summary of the results of a survey of potential applications of solar energy for supplying process heat requirements in the industrial, agricultural and commercial sectors of California is presented. Technical, economic and institutional characteristics of the three sectors are examined. Specific applications for solar energy are then discussed. Finally, implications for California energy policy are discussed along with recommendations for possible actions by the State of California.

**TU**  
**163.2**  
**.G74**  
**1978**

**Greater Los Angeles Area Energy Symposium, Los Angeles, 1978.**

**Greater Los Angeles Area Energy Symposium**

• Solar Irrigation — Present Status and Future Outlook — R. L. Alvis, L. L. Lukens, A. M. Perino, Sandia Laboratories

An alternate source to fossil fuel is needed for the future powering of the nation's irrigation pumps. This alternative must be economical to allow our agriculture to be competitive and maintain large exports to offset the effects of oil imports. In an effort to find an alternate, the Department of Energy is sponsoring a Solar Irrigation Program (SIP). Solar energy is a logical choice because insolation is usually abundant in areas requiring irrigation.

One experiment is being conducted in New Mexico and another is being constructed in Arizona. The New Mexico experiment is constructed near Willard, New Mexico. It produces approximately 25 hp continuously during the irrigation season to direct drive a turbine-type well pump which delivers enough water to irrigate 100 acres. It utilizes 6720 sq ft (625 m<sup>2</sup>) of distributive-type solar collectors to heat an oil heat transfer fluid. The hot fluid produced supplies a Rankine cycle engine and charges a unique design thermocline thermal storage system. The Arizona experiment will be a 150 kWe solar powered deep well irrigation facility which is currently under design and construction. Other experiments are being planned.

79A17416 ISSUE 5 PAGE 850 CATEGORY 44 78/00/00  
5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Some studies on an experimental solar pond  
AUTH: A/DIXIT, D. K.; B/SHIWALKAR, B. D.; C/DOKRAS, V. M.  
PAA: C/(Visvesvaraya Regional College of Engineering, Nagpur, India)

In: Sun: Mankind's future source of energy; Proceedings of the International Solar Energy Congress, New Delhi, India, January 16-21, 1978, Volume 2. (A79-17276 05-44) Elmsford, N.Y.: Pergamon Press, Inc., 1978, p. 1073-1077.

MAJS: /\*ENERGY STORAGE/\*SOLAR ENERGY CONVERSION/\*SOLAR PONDS (HEAT STORAGE)

MINS: / COST REDUCTION/ DENSITY DISTRIBUTION/ ECONOMIC FACTORS/ ENERGY TECHNOLOGY/ SALINITY/ TEMPERATURE DISTRIBUTION/ TEMPERATURE INVERSIONS/ THERMAL STABILITY

ABA: (Author)

ABS: Solar ponds seem to be the only solution for collecting and storing solar energy for mechanical power production at competitive cost which will make the commercial exploitation of these systems feasible. Solar radiation effects a considerable temperature rise in a nonconvecting pond of one meter depth. The pond is maintained nonconvecting when there is a temperature gradient in the pond, with the bottom warmer than the top, by means of a salt concentration gradient with greater density of the lower regions. Salt water at 45 C can be withdrawn for utilization from the pond bottom.

79A38653 ISSUE 16 PAGE 3023 CATEGORY 44  
78/00/00 15 PAGES UNCLASSIFIED DOCUMENT

UTTL: Performance study of a solar still in Valencia /Spain/  
AUTH: A/RIERA, J.; B/MARTINEZ-LOZANO, J. A.; C/TEJERINA, F.; D/TENA, F. PAA: D/(Valencia, Universidad, Valencia, Spain)

In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports, Volume 3. (A79-38576 16-44) Munich, Deutsche Gesellschaft fuer Sonnenenergie, 1978, p. 57-71.

MAJS: /\*DISTILLATION/\*DISTILLATION EQUIPMENT/\*PERFORMANCE PREDICTION/\*SOLAR HEATING/\*THERMODYNAMIC EFFICIENCY  
MINS: / ENERGY TECHNOLOGY/ GRAPHS (CHARTS)/ INSOLATION/ SITES/ SOLAR COLLECTORS

ABA: F.T.H.

ABS: An experimental study of a solar water distillation process was carried out in Valencia, Spain. Two stills were studied: (1) a low thermal inertia still provided with a floating absorber, and (2) a convection still. The low thermal inertia still had a production over 4% higher than the conventional still. The relationship between production and other parameters was derived, leading to an estimate for the annual production at Valencia.

## SOLAR POOL HEATERS

(No. 101) \$2.00

If you are planning to install a solar pool heater, or are just curious about them, this publication is a must. SOLAR POOL HEATERS starts with a description of how pools lose heat and ways to stop it. Then, it goes on to describe and evaluate many of the solar pool heating systems now on the market. Finally, you are shown how to design, build, and install your own do-it-yourself solar pool heater. Well illustrated, 32 Pages

79A17431 ISSUE 5 PAGE 852 CATEGORY 44 78/00/00  
5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Conditions for absolute stability of salt gradient solar ponds

AUTH: A/NIELSEN, C. E. PAA: A/(Ohio State University, Columbus, Ohio)

In: Sun: Mankind's future source of energy: Proceedings of the International Solar Energy Congress, New Delhi, India, January 16-21, 1978. Volume 2. (A79-17276 05-44) Elmsford, N.Y., Pergamon Press, Inc., 1978. p. 1176-1180. Research supported by the Ohio State University.

MAJS: /\*CONVECTION/\*FLUID BOUNDARIES/\*SOLAR PONDS (HEAT STORAGE)

MINS: / AQUEOUS SOLUTIONS/ ENERGY TECHNOLOGY/ INTERLAYERS/ SALINITY/ SURFACE LAYERS/ TEMPERATURE GRADIENTS/ TRANSITION LAYERS

ABA: V.P.

ABS: Salt-gradient-stabilized solar ponds normally consist of three zones: a convective surface layer, a nonconvective gradient zone, and a second convective layer at the bottom. The behavior of the convective-nonconvective zone boundaries determines the durability and thickness of the gradient zone and, hence, the reliability of the pond. In the present paper some previous work on salt gradient systems is reviewed. The origin of the convective zones in practical ponds is discussed, along with the nature of the boundaries. Data on the zone boundary behavior are examined, and the factors involved in the boundary behavior are discussed.

79A34085 ISSUE 13 PAGE 2420 CATEGORY 44 CNT#:  
EG-77-5-04-3977 78/00/00 33 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Heat extraction from a salt gradient solar pond  
AUTH: A/ZANGRANDO, F.; B/BRYANT, H. C. PAA: B/(New Mexico, University, Albuquerque, N. Mex.)

In: Alternative energy sources: Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. (A79-34067 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978. p. 2935-2967. Research supported by the New Mexico State Energy Resources Board.

MAJS: /\*ENERGY STORAGE/\*SOLAR COLLECTORS/\*SOLAR HEATING/\* SOLAR PONDS (HEAT STORAGE)

MINS: / GRAPHS (CHARTS)/ INDUSTRIAL ENERGY/ LOW COST/ SALINITY/ SODIUM CHLORIDES/ TEMPERATURE PROFILES

ABA: (Author)

ABS: A salt gradient solar pond is an efficient, low cost solar energy collection and long range storage system for low temperature heat. A full-scale demonstration salt gradient solar pond in operation for over two years is described. Operational parameters, selection criteria for the materials to be used, cost, performance, as well as the physical behavior of doubly-diffusive systems exposed to the environment are considered. Although the current research is primarily geared to space heating (which varies seasonally) and industrial process heating (which poses a constant demand), crop-drying, water desalination, cooling and electricity production are possible applications of the solar pond. In the second year of operation the large storage layer has reached a temperature of 93 C; this is a record high for sodium chloride ponds with storage. Heat has been successfully extracted from the 175 sq m pond on a daily basis since November 4, 1977.

79N10553# ISSUE 1 PAGE 74 CATEGORY 44 RPI#:  
NTIS/PS-78/0836/3 NTIS/PS-77/0458 78/08/00 31 PAGES  
UNCLASSIFIED DOCUMENT  
Updates NTIS/PS-77/0458

UTTL: Solar ponds. Citations from the NTIS data base  
TLSP: Progress Report, 1976 - Jun. 1978

AUTH: A/HUNDEMANN, A. S.  
CORP: National Technical Information Service, Springfield, Va. AVAIL NTIS GAP: HC \$28.00/MF \$28.00

MAJS: /\*BIBLIOGRAPHIES/\*SOLAR COLLECTORS/\*SOLAR PONDS (HEAT STORAGE)

MINS: / ABSTRACTS/ BIOMASS ENERGY PRODUCTION/ ELECTRIC POWER / INDUSTRIAL ENERGY

ABA: GRA

ABS: This bibliography contains 27 abstracts of federally-funded research reports on the design, performance, and use of solar ponds. Topic areas cover the use of solar ponds in industrial process heat production, roof ponds for passive solar buildings, and solar pond use in the production of biomass for renewable fuels.

Royal Society of London  
Philosophical Transactions,  
Ser.A, v.295, no.1414

Feb.7,  
1980

SOLAR ENERGY. (A discussion held Nov.15-16,1978.  
Organized by George Porter and William Hawthorne).

H. TABOR

Non-convecting solar ponds *P423-434*

A salt gradient is imposed on a black-bottomed pond about 1 m deep; this creates a density gradient (positive measured downwards) which suppresses convection when the pond is heated from the bottom by absorbed solar radiation. Between 15 and 25% of the incident radiation, depending upon pond cleanliness, reaches the bottom and can be decanted by stratified hydrodynamic flow of the bottom layer. Temperatures approaching the boiling point have been recorded. At 32° latitude and under Israel sunshine conditions, estimated annual thermal output from a pond of 1 km<sup>2</sup> is equivalent to 43000 t of fuel oil. A method of avoiding salt diffusion, which would slowly destroy the gradient, is described. Practical problems include suppression of surface mixing by wind and the possible effects of heating large areas of ground.

79N11497# ISSUE 2 PAGE 202 CATEGORY 44 RPT#:  
UCRL-52385 CNT#: W-7405-ENG-48 78/01/06 74 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Design guide for shallow solar ponds

AUTH: A/CASAMAJOR, A. B.; B/ARSONS, R. E.

CORP: California Univ., Livermore, Lawrence Livermore Lab.  
AVAIL NTIS SAP: HC A04/1F A01

MAJS: /\*ENERGY TECHNOLOGY/\*SOLAR PONDS (HEAT STORAGE)/\*  
STRUCTURAL DESIGN

MINS: / COMMERCIAL ENERGY/ COSTS/ DESCRIPTIONS/ EQUIPMENT  
SPECIFICATIONS/ INDUSTRIAL ENERGY/ MANAGEMENT PLANNING

ABA: DOE

ABS: The Solar Energy Group at LLNL developed shallow solar ponds to supply solar-heated water for industrial and commercial use at a cost that is competitive with conventional energy sources. Three aspects of the SSP technology are discussed: (1) an introduction to SSP technology, potential, and limitations; (2) a detailed description of the design and operation of an SSP system including component drawings and specifications; and (3) planning information so that an SSP system can be used for a particular application and the cost can be estimated.

#### TRACKING SOLAR FURNACE

Charles Curnutt,  
Popular Science, vol. 212, no., 4, April 1978  
p.24-26

One hundred mirrors focus sunlight onto water-filled boiler at top of array. Since heat is concentrated on very small area, insulation requirements are not as crucial as for flat-plate solar collectors.

TJ  
163.2  
.G74  
1978

Greater Los Angeles Area Energy Symposium, Los Angeles, 1978.

Greater Los Angeles Area Energy Symposium

• Solar Distillation -- E. Y. Lam, Bechtel National, Inc. *P.8*

This paper presents a technical and economic assessment of solar distillation. Using presently implementable technology, a 5-million-gallon-per day solar distillation plant was conceptualized. For present day plant construction, the distilled water cost is approximately \$7 to \$9 per 1000 gallons.

~~Proceedings~~  
series - Los Angeles Council of Engineers  
Scientists ; v. 4.

78N79748# CATEGORY 44 RPT#: UCRL-52397 CNT#:  
W-7405-ENG-48 78/04/03 26 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Engineering feasibility of a 150-kw irrigation pumping plant using shallow solar ponds

AUTH: A/PLATT, E. A.; B/WOOD, R. L.

CORP: California Univ., Livermore, Lawrence Livermore Lab.  
AVAIL NTIS

MAJS: /\*ENERGY POLICY/\*ENERGY TECHNOLOGY/\*IRRIGATION/  
PUMPING/\*SOLAR PONDS (HEAT STORAGE)

MINS: / FEASIBILITY ANALYSIS/ INSTALLING/ RANKINE CYC



# A SOLAR AIRSHIP - MORE THAN FLIGHT OF FANCY?

Gabriel Khoury & Edwin Mowforth

New Scientist, Vol. 79, No. 1111, July 13, 1978,  
p. 100-102.

ORIGINAL PAGE  
OF POOR QUALITY

Of all the alternative energy sources now being developed only solar energy can be reliably applied to vehicles without the need for cumbersome on-board energy storage systems. And of all the vehicles that can operate over all forms of terrain, only the airship has, inherently, a large enough surface area for significant

power to be generated by solar cells alone. With its additional property of static lift, so that energy is necessary only for direct propulsion, a solar powered airship, the Sunship, is a leading candidate for urgent development as a load carrier.

EMERGING ENERGY ALTERNATIVES FOR THE SOUTHEASTERN STATES. Elias K. Stefanakos, ed. (Symposium sponsored by DOE, LARC and NCA&TSU. Held NCA&TSU, Mar. 31, 1978) June 1978. 152p. NASA CP-2042

Department of Energy,  
Washington, D.C.  
NASA,

Langley Research Center  
North Carolina Agricultural and Technical  
State Univ., Greensboro, N.C.

AGRICULTURAL AND INDUSTRIAL PROCESS HEAT p. 59  
James Dollard

78A42164 ISSUE 18 PAGE 3297 CATEGORY 44  
77/00/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: Solar ponds for power production

AUTH: A/DIXIT, D. K.; B/SHIWALKAR, B. D. PAA:  
B/(Visvesvaraya Regional College of Engineering,  
Nagpur, India)

In: National Solar Energy Convention, Calcutta, India  
November 29-December 1, 1976. Proceedings. (A78-42101  
18-44) Calcutta, Jadavpur University, 1977. p.  
232-235.

MAJS: /\*BRINES/\*SOLAR ENERGY CONVERSION/\*SOLAR PONDS (HEAT  
STORAGE)

MINS: / ENERGY TECHNOLOGY/ MAGNESIUM CHLORIDES/ MATHEMATICAL  
MODELS/ POWER EFFICIENCY

ABA: D.M.W.

ABS: The operation of a water-deep, black-bottom water pool  
for the collection of solar thermal energy is  
discussed. Salt water is used in quantity near the  
bottom to maintain a density gradient. Water  
temperatures near 90 C can be obtained from the lower  
regions of the pool. Attention is given to the  
mechanisms of transient and steady-state temperature  
rise in the pool at various depths, optimization of  
water withdrawal rate, and overall thermal stability.

78A27860 ISSUE 10 PAGE 1793 CATEGORY 44  
77/00/00 16 PAGES UNCLASSIFIED DOCUMENT

UTTL: Solar pond

AUTH: A/SAVAGE, S. B. PAA: A/(McGill University, Montreal,  
Canada)

In: Solar energy engineering. (A78-27852 10-44) New  
York, Academic Press, Inc., 1977. p. 217-232.

MAJS: /\*ENERGY CONVERSION EFFICIENCY/\*HEAT EXCHANGERS/\*HEAT  
STORAGE/\*SOLAR PONDS (HEAT STORAGE)/\*WATER FLOW

MINS: / ENERGY TECHNOLOGY/ RECIRCULATIVE FLUID FLOW/  
RECYCLING/ SHALLOW WATER/ SOLAR COLLECTORS/ WATER  
TEMPERATURE

ABA: G.R.

ABS: It has been proposed that no convective solar ponds  
should be used for collecting and storing energy on a  
large scale. A solar pond is a shallow body of water  
about one meter deep containing dissolved salts to  
generate a stable density gradient with fresh water on  
top and denser salt water at the bottom. Part of the  
incident solar radiation entering through the pond  
surface is absorbed throughout the depth. The  
remainder which penetrates the pond is absorbed at the  
black bottom. The density gradient is used to suppress  
convection. Heat is, therefore, lost from the lower  
layers only by conduction. Energy can be extracted  
from the pond by recycling the water in the hot layers  
of the pond through a heat exchanger. A review is  
conducted concerning the previous work on solar ponds,  
taking into account the physical principles of their  
operation and the practical difficulties which would  
have to be overcome.

78A11270 ISSUE 1 PAGE 70 CATEGORY 44 77/00/00  
5 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Numerical simulation of a solar heated and cooled house using roof ponds and movable insulation  
AUTH: A/MILLER, W. C.; B/MANCINI, T. R. PAA: B/(New Mexico, State University, Las Cruces, N. Mex.)  
In: International Solar Energy Society, Annual Meeting, Orlando, Fla., June 6-10, 1977, Proceedings, Sections 1-13. (A78-11212 01-44) Cape Canaveral, Fla., International Solar Energy Society, 1977, p. 11-21 to 11-25. Research supported by the New Mexico Energy Resources Board.  
MAJS: /\*DIGITAL SIMULATION/\*DOMESTIC ENERGY/\*SOLAR COOLING/\*SOLAR HOUSES/\*SOLAR PONDS (HEAT STORAGE)/\*THERMAL INSULATION  
MINS: / ATMOSPHERIC TEMPERATURE/ CONCRETES/ HEAT TRANSFER/ ROOFS/ SOLAR HEATING  
ABA: (Author)  
ABS: The transient response of a solar heated and cooled house to hypothetical and actual weather conditions is modeled numerically using a lumped mass, energy balance technique. The house described in this paper utilizes a water pond located on the roof to collect and reject energy, and the thermal mass of the walls, ceiling and the water for energy storage. Movable insulation positioned above the water pond provides the control for the system in both the heating and cooling modes of operation. Results are presented in terms of the inside air temperature response for water depths ranging from near zero to 30.5 centimeters, concrete ceiling thickness from near zero to 20.3 centimeters and infiltration losses corresponding to zero, one half and one inside air change per hour.

TJ McVeigh, J. C.  
810 Sun power : an introduction to the  
.M2 applications of solar energy / J. C.  
1977 McVeigh, -- Oxford ; New York : Pergamon  
Press, 1977.

The introductory material, for new-comers to the field, is excellent, as are the synopses of principles and developments. Yet this small book (215 pages) is surprisingly comprehensive. It contains three times as much up-to-date and factual information as in most other books on solar energy. For example, McVeigh describes in some detail the recently invented below-atmospheric-pres-

sure collector of Prof. Donald L. Spencer at the University of Iowa, a revolutionary design still little-known. Although the book does not have the encyclopedic coverage of the 650-page *Applied Solar Energy* by Aden B. and Marjorie P. Meinel, it stands high above that book in clarity and accuracy.

78A11300 ISSUE 1 PAGE 73 CATEGORY 44 77/00/00  
5 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Stability criteria for solar /thermal-saline/ ponds  
AUTH: A/ELWELL, D. L.; B/SHORT, T. H.; C/DADGER, P. C.  
PAA: C/(Ohio Agricultural Research and Development Center, Wooster, Ohio)  
In: International Solar Energy Society, Annual Meeting, Orlando, Fla., June 6-10, 1977, Proceedings, Sections 14-25. (A78-11212 01-44) Cape Canaveral, Fla., International Solar Energy Society, 1977, p. 16-29 to 16-33.  
MAJS: /\*PERFORMANCE TESTS/\*SODIUM CHLORIDES/\*SOLAR PONDS (HEAT STORAGE)/\*THERMAL STABILITY  
MINS: / NUMERICAL INTEGRATION/ SALINITY/ TEMPERATURE GRADIENTS  
ABA: (Author)  
ABS: Maximization of solar (thermal-saline) pond performance requires detailed information on thermal stability limits for the particular salt in use in the pond. The stability equations of Turner and Weinberger were used to calculate maximum thermal gradients that can be supported in sodium chloride stabilized systems under various conditions. Limited experimental tests are devised for the validity of these calculations. Such systems should be stable up to a peak temperature of 100 C for a maximum salt concentration as low as 12 percent by weight.

77A26489# ISSUE 10 PAGE 1676 CATEGORY 44 RPT#:  
ASME PAPER 76-WA/HT-62 76/12/00 6 PAGES  
UNCLASSIFIED DOCUMENT  
UTTL: Exploring stability criteria of solar ponds.  
AUTH: A/HAUSER, S. G. PAA: A/(Oregon State University, Corvallis, Ore.) SAP: MEMBERS, \$1.50; NONMEMBERS, \$3.00  
American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Dec. 5-10, 1976. 6 p.  
MAJS: /\*FREE CONVECTION/\*SALINITY/\*SOLAR PONDS (HEAT STORAGE)/\*THERMAL STABILITY  
MINS: / CONVECTIVE FLOW/ ENERGY TECHNOLOGY/ TEMPERATURE GRADIENTS  
ABA: G.R.  
ABS: The thermal energy which can be retained by solar ponds is reduced by convective motions. An investigation is conducted regarding the possibility to prevent such motions by making use of salt water systems with a suitable salt concentration gradient which ensures that the solution is more dense at the bottom even when warmed by solar radiation. Under certain conditions oscillatory motions will set in and destroy the concentration gradient. Attention is given to criteria which provide information concerning the magnitude of the salt concentration gradient required to prevent such oscillatory motions.



77A41851 ISSUE 19 PAGE 3247 CATEGORY 44  
77/08/00 3 PAGES UNCLASSIFIED DOCUMENT

UTTL: Solar ponds - Low cost solar energy management systems  
AUTH: A/SHAFFER, L. H.  
Energy, vol. 2, Summer 1977, p. 18-20.  
MAJS: /\*COST ANALYSIS/\*ENERGY CONVERSION EFFICIENCY/\*SOLAR  
PONDS (HEAT STORAGE)  
MINS: / COST EFFECTIVENESS/ ENERGY TECHNOLOGY/ LOW COST/  
MANAGEMENT SYSTEMS/ SOLAR CELLS/ SOLAR COLLECTORS  
ABA: C.K.D.  
ABS:

The large areas required to obtain significant amounts of heat or work from solar energy lead to high collector costs. A five- to tenfold reduction in manufacturing costs of photovoltaic silicon devices would bring the cost of DC energy without storage to \$500/peak kW, assuming an efficiency of 10%; flat collectors for solar-based heat cost \$20-30/sq. ft. Solar ponds represent an approach which combines long term storage with low cost: \$4 to \$10/sq. ft. Three types of solar ponds - the salt stabilized solar pond, the shallow solar pond developed at the Lawrence Livermore Laboratory, and the viscosity stabilized pond - are discussed. The costs of each type of system are estimated. Difficulties which may be encountered in the construction and operation of solar ponds are considered.

78N28653# ISSUE 19 PAGE 2561 CATEGORY 44 RPT#:  
SAND-77-8176 CNT#: EY-76-C-04-0789 77/12/00 81  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Technical and economic assessment of solar  
distillation for large scale production of fresh water  
TLSP: Final Report  
CORP: Bechtel Corp., San Francisco, Calif. AVAIL:NTIS  
SAP: HC A05/MF A01  
MAJS: /\*DISTILLATION/\*ECONOMIC ANALYSIS/\*SOLAR ENERGY/\*  
TECHNOLOGY ASSESSMENT/\*WATER TREATMENT  
MINS: / DISTILLATION EQUIPMENT/ HEAT STORAGE/ POTABLE WATER/  
SOLAR COLLECTORS/ SOLAR HEATING  
ABA: ERA  
ABS:

An assessment of solar distillation plant performance attainable with presently implementable technology is presented. A review of existing technology provides the basis for selection of the design for a 5 million gallon per day solar distillation plant. The cost of distilled water from this plant is compared with the cost of water from an oil fired distillation plant of the same installed capacity. For present day plant construction and annual fuel escalation rates below 10.5 percent, water obtained from a solar driven distillation plant is more expensive than that obtained from conventional oil driven distillers.

TH  
7413  
.P37

Solar heating and cooling : recent  
advances / J. K. Paul. -- Park Ridge, N.J.  
: Noyes Data Corp., c1977.  
- x, 485 p. : ill. ; 24 cm. (Energy  
technology review ; no. 16)

SWIMMING POOL APPLICATIONS .....	433
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78N28544# ISSUE 19 PAGE 2547 CATEGORY 44  
77/00/00 12 PAGES UNCLASSIFIED DOCUMENT DCAF  
E014186

UTTL: Solar desalination: Status and potential  
AUTH: A/MUSTACCHI, C.; B/CENA, V.  
CORP: Rome Univ. (Italy). AVAIL:NTIS SAP: HC A99/MF A01  
In WMO Solar Energy p 507-518 (SEE N78-28501 19-42)  
MAJS: /\*DESALINIZATION/\*SOLAR ENERGY/\*SOLAR GENERATORS/\*  
WATER  
MINS: / COST ESTIMATES/ ENERGY STORAGE/ EVAPORATORS/  
TECHNOLOGY UTILIZATION/ THERMAL ENERGY  
ABA: Author (ESA)  
ABS: Freshwater can be produced by means of solar energy at a cost of 1 to 1.7 \$/cu m with a margin of the order of 5% towards fossil-fired operation. This concerns plants having a nominal production of at least 50 cu m/hr and the multistage flash evaporator concept. For much smaller capacities, basin stills, at a cost of 2 \$/cu m, are a convenient low-technology solution. These margins will increase to 30% within the next ten years, and can even lead to better prospects provided that priority is given to the present bottlenecks of this technology; namely, increasing lifetime and reliability, designing an appropriate heat storage system, improving the dynamics of startup and shutdown for the plants.

A78-27860 Solar pond. S. B. Savage (McGill University, Montreal, Canada). In: Solar energy engineering. (A78-27852 10-44) New York, Academic Press, Inc., 1977, p. 217-232.

It has been proposed that nonconvective solar ponds should be used for collecting and storing energy on a large scale. A solar pond is a shallow body of water about one meter deep containing dissolved salts to generate a stable density gradient with fresh water on top and denser salt water at the bottom. Part of the incident solar radiation entering through the pond surface is absorbed throughout the depth. The remainder which penetrates the pond is absorbed at the black bottom. The density gradient is used to suppress convection. Heat is, therefore, lost from the lower layers only by conduction. Energy can be extracted from the pond by recycling the water in the hot layers of the pond through a heat exchanger. A review is conducted concerning the previous work on solar ponds, taking into account the physical principles of their operation and the practical difficulties which would have to be overcome.

G.R.

QC  
1  
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1977  
v.2  
International Summer College on Physics and  
Contemporary Needs, 2d, Nathia Gali,  
Pakistan, 1977.  
Physics and contemporary needs, v. 2 /  
...cl<sup>1978</sup>

Feasibility Aspects of Solar Energy Conversion *B283-304*.  
I. F. Querica

77A42956 ISSUE 20 PAGE 3450 CATEGORY 44  
77/00/00 5 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Optimum design of a single slope solar still in  
Riyadh, Saudi Arabia  
AUTH: A/SAYIGH, A. A. M.; B/EL-SALAM, E. M. A. PAA:  
B/(Riyadh, College of Engineering, Riyadh, Saudi  
Arabia)  
Cooperation Mediterranee pour l'Energie Solaire.  
Revue Internationale d'Heliotechnique, no. 1, 1977, p.  
40-44.  
MAUS: /\*DESIGN ANALYSIS/\*SAUDI ARABIA/\*SOLAR ENERGY  
CONVERSION/\*STILLS  
MINS: / ENERGY CONVERSION EFFICIENCY/ SOLAR ENERGY ABSORBERS  
ABA: P.T.H.  
ABS: The performance of seven reinforced-concrete solar  
stills in Saudi Arabia was compared. The stills varied  
with respect to thickness of glass cover, cover slope,  
absorbant materials, and sealing agent between the  
glass cover and the frame. Absorbant materials were  
red sand, black sand, straw, black dye, and charcoal.  
A still with 20-deg slope cover gave best performance.  
This still was tested with different absorbants, and  
the use of black stone yielded highest output. This  
still yields 1.5 liters/day and its yearly average  
efficiency is 45 percent.

## TECHNICAL NOTE -- A SOLAR POND FOR LONDON? H. C. Bryant and Ian Colbeck

Solar Energy, vol. 19, no. 3, 1977, p. 321  
- 322

Often the critical difficulty with solar energy is that, when it is most abundant, it is least needed, especially in the heating of living spaces. Recently interest in the possibilities of solar ponds has been revived by the work of Rabi and Nielsen[1], who point out that salt-gradient ponds, with their long time constants, are particularly suited for residential heating. Rabi and Nielsen have derived formulas[1] for the essential parameters of a type of salt-gradient pond, which we shall call the Rabi-Nielsen (R.N.) pond. The R.N. pond consists of two water layers: an upper non-convecting layer, a metre or more thick, in which a salt concentration gradient allows the establishment of a temperature gradient (hot on the bottom, cold on top) and a lower convecting layer, also a metre or so thick, which serves as a storage bin for solar heat. The short and medium wavelengths in the solar spectrum are absorbed throughout the pond and on its black bottom, and thereby contribute to the useful energy collected by the pond. The long wavelength (IR) component of the solar spectrum, very strongly absorbed by water, is removed by the low temperature surface of the pond and is quickly lost. The loss of the IR component is the penalty one must pay for a very desirable feature of this system: heat generated deep in the pond cannot be reradiated. Since the upper layer is non-convecting, the only remaining mechanism is conduction, and for water the conductivity is quite low.

## THE USE OF WATER RESERVOIRS, LAKES AND BAYS FOR SHALLOW POND COLLECTORS AND SUBMERGED HOT WATER STORAGE.

G. Grevskott  
Solar Energy  
Vol. 19 no.6  
p.777-778

1977.

In most areas surface temperatures of lakes and oceans reach a maximum of 23°C as a result of heat losses through radiation, convection, conduction and evaporation. By covering the surface with a clear plastic sheet and by insulating the top layer from the bulk of the water by using foam plastic or another material, the surface will operate as a floating shallow pond and obtain temperatures as for similar land based collectors. In this way no land area is occupied and therefore the collector may be used in densely populated areas provided a water surface is located close by. The collected hot water may be fed into a district heating system, used as process water in industry and for cooling purposes.

# FLOW SYSTEM FOR MAINTENANCE OF SALT CONCENTRATION GRADIENT IN SOLAR PONDS--TEST IN ISOTHERMAL POND.

C. E. Nielsen, A. R. Rabl, J. Watson and P. Weiler

Solar Energy  
Vol. 19 no. 6  
p.763-766

1977.

Solar ponds[1] have been proposed as solar collectors for power production[2] and process heat[3] and as energy collection and long term storage systems for space heating[4]. In order to maintain the salt concentration gradient it has been suggested that the surface may be "washed with fresh water or weak solution (sea water) with some overflow" and that concentrated solution "may be injected into the bottom of the pond from time to time." (Quoted from Ref. [2]) A similar combination of surface washing and concentrated brine input at lower levels is presumably responsible for the salt gradient in the naturally occurring salt gradient lakes first studied by Kalcsinsky[5].

77B10276\* CATEGORY 3 NPO-13581 77/11/00  
UNCLASSIFIED DOCUMENT DOMESTIC

UTTL: "Solar ponds"

UNOC: (Array uses low-cost materials and heavy construction methods to make collection and storage of solar energy economical on large scale required for commercial operation. Series of long trenches are dug side by side over an area large in comparison to heat diffusivity of soil.)

AUTH: A/MILLER, C. G.; B/STEPHENS, J. B.

MAJS: /\*ELECTRIC POWER PLANTS/\*HEAT STORAGE/\*SOLAR ARRAYS/\*  
SOLAR COLLECTORS/\*SOLAR ENERGY

## SOLAR PONDS: HEAT FROM A HOLE IN THE GROUND. Ed Nelson.

Popular Science, Dec.1977, p.80-81.

Solar radiation, penetrating fresh and low-salt nonconvective layers, warms this pond's salty bottom layer. Fresh water pumped through pipes receives and carries off stored heat.

79N70505\* CATEGORY 44 RPT#: ERDA-TR-317 77/00/00  
19 PAGES UNCLASSIFIED DOCUMENT

UTTL: Solar distillation of water

CORP: Energy Research and Development Administration,  
Washington, D. C. AVAIL:NTIS

Transl. into ENGLISH of "A distillation Solaire des  
Eaux", unidentified French report

MAJS: /\*DISTILLATION/\*SOLAR FURNACES/\*WATER  
MINS: / EQUIPMENT SPECIFICATIONS/ SEA WATER

A78-27861 Solar furnaces. T. Sakurai (Tohoku University,  
Sendai, Japan). In: Solar energy engineering. (A78-27852 10-44)  
New York, Academic Press, Inc., 1977, p. 233-262.

A solar furnace is a device for applying high temperatures to a specimen by concentrating solar radiation on it. A brief historical review concerning the development of solar furnaces is presented and fundamental operational and design principles for solar furnaces are discussed. A paraboloidal mirror is used as a radiation concentrator of the reflection type. According to the procedures used to keep the solar radiation incident upon a concentrator, parallel to the optical axis, solar furnaces can be divided into two types. In a furnace of the direct-incidence type, the concentrator itself is directed towards the sun. In the heliostat type, the radiation is directed into a fixed concentrator by means of a turnable mirror or 'heliostat'. Attention is given to the three sun-following methods used, the theoretical relations concerning the concentration of the solar energy by a paraboloidal mirror, design examples for solar furnaces, and high-temperature investigations involving the use of a solar furnace. G 2

## THERMOMIGRATION OF SILICON WAFERS IN A SOLAR FURNACE.

H. E. Cline and T. R. Anthony.  
Solar Energy.

Vol. 19 no. 6 1977  
p.715-719.

Abstract—A 5.5 m, 8.7 kW solar furnace was designed and constructed to process silicon wafers by thermomigration. Under the intense heat, 160 W/cm<sup>2</sup>, of the solar furnace, a grid of aluminum wires was migrated through the wafer in 5 min. Helium gas was used to cool the wafer and produce a thermal gradient of 400°C/cm. The heat transfer and efficiency of the system are discussed.

(SAND--77-8176) TECHNICAL AND ECONOMIC  
ASSESSMENT OF SOLAR DISTILLATION FOR LARGE  
SCALE PRODUCTION OF FRESH WATER. FINAL  
REPORT. (Bechtel Corp., San Francisco, Calif.  
(USA)). Dec 1977. Contract EY-76-C-04-0789.  
81p. Dep. NTIS, PC A05/MF A01.

An assessment of solar distillation plant performance attainable with presently implementable technology is presented. A review of existing technology provides the basis for selection of the design for a 5 million gallon per day solar distillation plant. The cost of distilled water from this plant is compared with the cost of water from an oil fired distillation plant of the same installed capacity. For present day plant construction and annual fuel escalation rates below 10.5%, water obtained from a solar driven distillation plant is more expensive than that obtained from conventional oil driven distillers. For plants constructed in the future, the continued escalation of fuel oil cost at annual rates exceeding 5% will make the cost of water from solar driven and oil driven distillers equal within 15 years.

SEA WATER DESALINATION WITH SOLAR ENERGY. Heidtmann, U. (Sueddeutsche Metallwerke G.m.b.H., Walldorf (Germany, F.R.). Abt. Solar-Technik). pp 349-362 of 1st German solar energy forum. Vol. 2. Proceedings. Chapter 17: solar power stations. Bossel, U. (ed.). Muenchen, Germany, F.R.: DGS (1977). (In German)

From 1. German solar forum with exhibition; Hamburg, Germany, F.R. (23 - 28 Sep 1977).

The fact that desert areas belong to the sunnier areas on the earth may justify the use of the solar energy for water heating. Most of the so far developed systems use solar energy to evaporate boiler water. Further reports will be furnished as regards technologically simpler water desalination plants according to the greenhouse type and plants with a higher capacity with heat pipe collectors and flat plate collectors in connection with multiple stage evaporation plants.

(ERDA-tr-317) SOLAR DISTILLATION OF WATER. [nd]. Translation of a French paper. 19p. Rep. NTIS, PC A02/MF A01.

The solar furnace for distilling sea water is characterized by the fact that it consists of a large-area horizontal rack located at a certain distance above the ground, a foundation which is made up of juxtaposed panels that can be turned toward the bottom to recover salt deposits, and which is topped by a metal grating in which links are situated at regular intervals, and convergent lenses at an appropriate focal distance, above which inclined elongated mirrors are arranged; of these the largest area is north-south oriented. The forces of the realization of a solar furnace are characterized by the following points, either alone or in combination: the horizontal rack consists of the solar furnace properly supplied with sea water by nozzles, preferably cylindrical, joined to the sides by a divergent member made of reinforced concrete and eventually by the intermediary of aspiration pumps; the produced steam is aspirated in a large expansion chamber which is connected to the side of the rack opposite the divergent member and extending member from a convergent member which feeds a condenser; Pipes, preferably made of brass, are interconnected to form a coil for generating steam and are situated on the bottom of the horizontal rack, making up at least a part of the longitudinal equipment; the steam generated by the coil furnishes the power to drive a thermal power station which supplies the auxiliary machines of the installation, particularly the condenser and the aspiration pumps. (MHR)

CN-142,928

1977  
PROJECT SUNRISE: THE WORLD'S FIRST SOLAR POWERED AIRCRAFT. Robert J. Boucher. Jan. 1977. 6p.

Radio Control Modeler, v. 14,  
no. 1, p. 98-101, 118, 122  
(Photocopy)

Jan.  
1977

Airplanes, Pilotless  
Sunrise project

Gliders - Astro Flight 7404

TJ  
710  
.B46  
1977

Berens, Justin A.

Survey of the emerging solar energy industry / compiled and written by Justin A. Berens ; edited by Francis deWinter. -- 1977 ed. -- San Mateo, Calif. : Solar Energy Information Services, c1977. xi, 405 p. : ill. : 2° cm. Bibliography: p. 369-377.

## VI. HEATING AND COOLING - INDUSTRIAL PROCESS HEAT..... 96

P96-106

A SOLAR STOVE OF TIN PLATE, by W. I. Gripenberg.  
HOW TO BUILD A SOLAR COOKER, by Dr. C. G. Abbot.  
The Mother Earth News, no. 45, May/June 1977,  
p. 88-89.

THE CAN-TYPE SOLAR HOT-AIR FURNACE.  
Bruce Hilde.

Alternate Sources of Energy, no. 26, June 1977,  
p. 6-11.



ASHRAE Journal, v.19, no.11

Nov.  
1977

### SOLAR TECHNOLOGY: UPDATE '77.

W. Stephen Comstock

TRENDS: COMMERCIAL/INDUSTRIAL APPLICATIONS SPUR  
SOLAR DEVELOPMENT.

pp.32-34

**D**URING the past several years, increased application of solar energy systems has become evident in the commercial and industrial sectors. Described below are significant projects in these areas. Additional information on each is available from the Editor, ASHRAE JOURNAL.

### SOLAR-POWERED IRRIGATION STAFF ED. Samuel Walters

Mechanical Engineering, June 1977, vol. 99,  
no. 6, p. 52

N78-29810# Ohio Agricultural Research and Development  
Center, Wooster.

#### PROCEEDINGS OF A CONFERENCE ON SOLAR ENERGY FOR HEATING GREENHOUSES AND GREENHOUSE- RESIDENTIAL COMBINATIONS

T. E. Bond, L. C. Godbey, H. F. Zornig, and Ted H. Short, ed.  
Nov. 1977 350 p. refs. Proc. held at Cleveland, 20-23 Mar.  
1977 Prepared in cooperation with DoE, Washington, D. C.  
(CONF-770367) Avail. NTIS HC A15/MF A01

A research and development effort is reported that evaluates the feasibility of heating and cooling greenhouses and greenhouse-residential combinations by solar energy conversion. Energy research and energy policy abstracts represent the current state of the art.

G.G.

### SOLAR POWER FOR INDUSTRIAL PROCESS HEAT William C. Dickinson

Energy and Technology Review

Vol.

no.

Nov/Dec 1977

p. 20-27

American industry annually burns the equivalent of 30 million barrels of oil just to heat water. Generating steam takes roughly another 650 million barrels. Solar energy could supply much of this hot water and steam, saving enormous quantities of nonrenewable fossil fuel, if solar collectors were less expensive to build.

In our solar power development, we have been concentrating on ways to reduce the capital cost. The cost of expanding our prototype shallow solar ponds—now at the end of their second year of operation near Grants, New Mexico—to a full-scale operating system is within about 25% of the breakeven price based on current oil prices. The experimental solar steam generator we are about to begin testing should cost from one-tenth to one-fifth as much as other currently funded DOE solar steam systems. We can achieve these economies by constructing the system from inexpensive materials and by eliminating the need to track the sun.

### AN ORBITING MIRROR FOR SOLAR ILLUMINATION AT NIGHT

William R. Rush  
Solar Energy

Vol. 19 no. 6  
p.767-773

1977.

It is being proposed here that solar energy be employed directly to provide nighttime illumination for large urban areas. The essence of this concept is to place a series of large, flat, light-weight mirrors of very simple design and construction into geostationary orbit to provide directly reflected sunlight for ground illumination at night. This proposal offers several advantages:

1. The reflecting surface can be a thin foil or aluminized sheet so that cost and weight are low.
2. No technological breakthroughs are required.
3. Since the reflector is a simple, almost passive device, there are few components to age and the expected lifetime is very long.
4. The fluxes involved are low and there is absolutely no danger of accidental pointing error.
5. The high efficiency with which solar energy is used enables one to have a relatively small collecting area.

TJ  
163.2  
.P4P Perspectives on the energy crisis : technical, regulatory, environmental, economic, prospective. / advisory editors, Howard Gordon, Roy Meador. — Ann Arbor, Mich. : Ann Arbor Science Publishers, c1977.

SOLAR ENERGY: TECHNOLOGY AND APPLICATION . . . . . 189

(From *Solar Energy: Technology and Applications*, Revised Edition, by J. Richard Williams, Associate Dean for Research, College of Engineering, Georgia Institute of Technology, Atlanta. Published by Ann Arbor Science Publishers, Inc., 1977) I.

Solar energy is presented as a reality whose time has arrived for implementation and use. The dramatic figures for incoming solar energy provide convincing proof of the sun's awesome bounty, if the technology of utilization is made available. Where solar energy development now is in terms of technology and costs is discussed. Tables of average daily solar radiations on a monthly basis for areas across the U.S. are given. For heating and cooling applications, solar energy is advocated now in many parts of the U.S. to replace nuclear and fossil fuel sources.

ENERGY SITUATION OF PUERTO RICO: ENERGY INITIATIVES . . . . . 195

(By the Office of Petroleum Fuels Affairs, Commonwealth of Puerto Rico)

The unique Puerto Rican geographic suitability for research advances in various energy directions (ocean thermal, wind, solar) is indicated in these initiatives. Specific locations are named where individual initiatives may be implemented.

32814 (STU—77-4084(Supp.8)) Technological limits for the utilization of solar energy. Ehrensaerd, G. (Ingenjörsvetenskapsakademien, Stockholm (Sweden)). Dec 1977. 62p. Dep. NTIS (US Sales Only). PC A04/MF A01.

A survey of the technological limits for the utilization of solar energy is given. It is stated that solar energy in the long run is the only single, reliable and continuous energy source at disposal for human being on earth. Its yearly contributions harvested by known and advanced technology is definitely limited, yet may be shared to mutual advantages by a limited number of people at an advanced stage of future development. The stage is definitely set for a level of 2 billion persons sharing at best  $40 \times 10^{12}$  kWh/year, not more.

## SOLAR ENERGY UPDATES.

Electro-Optical Systems Design, vol. 9, no. 2, February 1977, p. 12-13

Recent advances in solar energy utilization in this country and abroad, particularly in Israel.

TJ  
810  
J79  
1977 Aspen Energy Forum, 4th, Aspen Institute for Humanistic Studies, 1977.  
Solar architecture : proceedings of the Aspen Energy Forum 1977, May 27, 28, and 29, 1977, Aspen, Colorado / editors, Gregory E. Franta, Kenneth R. Olson ; graphics, T. Michael Manchester. — Ann Arbor, Mich. : Ann Arbor Science Publishers, c1978.

## GREENHOUSE

### GREENHOUSE CONSTRUCTION WORKSHOPS

"BARN RAISING STYLE" . . . . . 119  
William F. Yanda

ENERGY FLOWS IN THE GREENHOUSE . . . . . 123  
Herbert A. Wade

WET-DIRT STORAGE FOR A SOLAR GREENHOUSE . . . . . 133  
Joseph B. Orr

AN ATTACHED SOLAR-HEATED GREENHOUSE . . . . . 143  
H. E. "Rip" Van Winkle

78N77096# CATEGORY 44 RPT#: BNWL-1891 CNT#: AT(45-1)-1830 75/01/00 79 PAGES UNCLASSIFIED DOCUMENT

UTTL: The nonconvecting solar pond: An overview of technological status and possible pond application  
AUTH: A/STYRIS, D. L.; B/ZAWOREKI, R.; C/HARLING, D. K.  
CORP: Battelle Pacific Northwest Labs., Richland, Wash.  
AVAIL: NTIS

MAJS: /\*SOLAR ENERGY/\*SOLAR PONDS (HEAT STORAGE)  
MINS: / COST ANALYSIS/ ENERGY CONVERSION EFFICIENCY/ SOLAR RADIATION



77A23447 ISSUE 9 PAGE 1438 CATEGORY 44  
76/00/00 9 PAGES UNCLASSIFIED DOCUMENT

UTTL: Absorption cycles for air-cooled solar air conditioning

AUTH: A/PHILLIPS, B. A. PAA: A/(Phillips Engineering Co., St. Joseph, Mich.)  
(American Society of Heating, Refrigerating and Air-Conditioning Engineers, Semiannual Meeting, Dallas, Tex., Feb. 1-5, 1976.) ASHRAE Transactions, vol. 82, pt. 1, 1976, p. 966-974.

MAJS: /\*AIR CONDITIONING/\*AIR COOLING/\*COOLING SYSTEMS/\*  
ENERGY ABSORPTION/\*SOLAR ENERGY CONVERSION/\*  
THERMODYNAMIC CYCLES

MINS: / DISTILLATION/ EVAPORATION/ HEAT EXCHANGERS/ HIGH  
TEMPERATURE/ LOW TEMPERATURE/ THERMODYNAMIC EFFICIENCY

ABA: B.J.

ABS: A study is presented of solar air conditioning systems based on ammonia-water as the refrigerant-absorbent pair, with particular attention given to the types of absorption cycles which may be suitable. The use of double effect distillation, double evaporation, and heat recuperation for improving cycle efficiency is discussed. Cycles that have been previously used in residential air conditioning systems can achieve coefficients of performance in the 0.55-0.7 range under 95 F rating conditions. Coefficients of performance up to 0.88 are obtainable by applying cycles that have been used primarily in large tonnage industrial equipment.

1976  
CN-142,794  
SOLAR POOL HEATERS AND OTHER WAYS TO CUT YOUR POOL  
HEATING BILLS. 32p. 1976.

Horizon Industries,  
(North Hollywood, Calif.)

Solar collectors

Swimming pools

Power sources, Solar - Heating & cooling

1976  
CN-142,794

SOLAR POOL HEATERS AND OTHER WAYS TO CUT YOUR POOL  
HEATING BILLS. 32p. 1976.

Horizon Industries,  
(North Hollywood, Calif.)

Solar collectors

Swimming pools

Power sources, Solar - Heating & cooling

TJ Solar thermal and ocean thermal...c1976.  
810 (Card 2)

.S48

1976

v.5

Includes bibliographical references.  
1. Solar energy—Congresses. 2. Solar  
heating—Congresses. 3. Ocean thermal  
power plants—Congresses. I. Boer, Karl  
Wolfgang, 1926- II. International  
Solar Energy Society. American Section.  
III. Solar Energy Society of Canada. IV.  
Series.

SOLAR POND STABILITY EXPERIMENTS

188

DEVELOPMENTS IN SOLAR ENERGY UTILISATION IN THE UNITED  
KINGDOM

J.C. McVeigh

Solar Energy, v.18, no.5, p.381-385, 1976

Abstract—The United Kingdom is situated such that, until recently, it has been regarded as an unsuitable location for applications of solar energy. However, a considerable amount of work has been carried out over the past twenty years and, more recently, there has been a tremendous increase in all areas of activity. The broad conclusions which can be drawn from the work so far indicate that solar energy could make a significant contribution to the energy requirements of the United Kingdom.

CM-142,605, v.1-3 1976  
 ARMY SCIENCE CONFERENCE PROCEEDINGS. VOLUME I:  
 PRINCIPAL AUTHORS A THRU G. VOLUME II: PRINCIPAL  
 AUTHORS H THRU M. VOLUME III: PRINCIPAL AUTHORS  
 N THRU Z. (Held U.S. Military Academy, West Point,  
 N.Y., June 22-25, 1976). 1976. 432p. 480p. 426p

Department of the Army  
 Conference on Army Science

Conferences - Army  
 Conferences - Science

Remote Portable Solar Powered 1 89  
 Microwave System

TJ Agriculture, biomass, wind, new developments  
 810 : joint conference, American Section,  
 .S48 International Solar Energy Society and  
 1976 Solar Energy Society of Canada, inc.,  
 v.7 August 15-20, 1976, Winnipeg / editor, K.  
 W. Boer. -- Cape Canaveral, Fla. : American  
 Section of the International Solar Energy  
 Society, c1976.

APPLICATION OF CHEMICAL ENGINEERING TO 364  
 LARGE SCALE SOLAR ENERGY

BEAM-DAYLIGHTING: DIRECT USE OF SOLAR 375  
 ENERGY FOR INTERIOR LIGHTING

TJ Solar Energy Seminar, University of  
 810 Regina and University of Saskatchewan,  
 .S49 1976. 1976  
 Applications of solar energy :

proceedings of the Solar Energy  
 Seminar / editor, Peter J. Catania.  
 Regina, Sask. : University of Regina,  
 Canadian Plains Research Center, 1976.  
 165 p. : ill. ; 23 cm. (Canadian  
 plains proceedings ; 3 0317-6401)

1.5 Solar Grain Drying.  
 Gregg J. Schoneau, Faculty of Engineering, University  
 of Saskatchewan, Saskatoon, Saskatchewan . . . . . 85

TJ Solar thermal and ocean thermal...c1976.  
 810 (Card 2)  
 .S48 Includes bibliographical references.  
 1976 1. Solar energy--Congresses. 2. Solar  
 v.5 heating--Congresses. 3. Ocean thermal  
 power plants--Congresses. I. Boer, Karl  
 Wolfgang, 1926- II. International  
 Solar Energy Society. American Section.  
 III. Solar Energy Society of Canada. IV.  
 Series.

CONCENTRIC TUBE SOLAR STILL 210

TJ Solar thermal and ocean thermal : joint con-  
 810 ference, American Section, International  
 .S48 Solar Energy Society and Solar Energy Soci-  
 1976 ety of Canada, Inc., August 15-20, 1976,  
 v.5 Winnipeg / editor, K. W. Boer. -- Cape  
 Canaveral, Fla. : American Section of the  
 International Solar Energy Society. c1976  
 SOLAR INDUSTRIAL STEAM 203

STUDY OF A SOLAR ASSISTED DIFFUSION 220  
 SEPARATION PROCESS FOR ISOTOPIC  
 MIXTURES

77A49026 ISSUE 23 PAGE 4007 CATEGORY 44  
76/00/00 14 PAGES UNCLASSIFIED DOCUMENT

UTTL: Experience with a prototype solar pond for space heating

AUTH: A/NIELSEN, C. E. PAA: A/(Ohio State University, Columbus, Ohio)

In: Sharing the sun: Solar technology in the seventies; Proceedings of the Joint Conference, Winnipeg, Canada, August 15-20, 1976. Volume 5. (A77-48910 23-44) Cape Canaveral, Fla., International Solar Energy Society, 1976, p. 169-182. Research supported by the Ohio State University.

MAJS: /\*COST ESTIMATES/\*PERFORMANCE PREDICTION/\*PROTOTYPES/\* SOLAR HEATING/\*SOLAR PONDS (HEAT STORAGE)

MINS: / ANNUAL VARIATIONS/ CONVECTIVE FLOW/ ECONOMIC ANALYSIS/ S-STEMS ENGINEERING/ TEMPERATURE DISTRIBUTION/ WATER TEMPERATURE

ABA: (Author)

ABS: A solar pond of 2.5 m depth and 200 sq m area has been operated since Aug. 1975. It was conceived as an economic prototype, and commercial construction cost is estimated at \$7500; heat calculated available for winter use is 50,000 kw-hr thermal. To determine performance, the distributions of temperature in pond and earth and of salinity have been recorded. Behavior of surface and internal convection layers has been studied, and methods for eliminating them have been explored. Heating of sloping black walls may be troublesome but can be eliminated by design modification. Algae growth and contamination by leaves have occurred but appear manageable. Because of the late start, no heat was extracted last winter. Minimum pond temperature under ice and snow cover was 28 C in Feb. 1976; in June it reached 62 C. On the whole, performance to date is encouraging.

# SOIAR WATER PUMP FOR LIFT IRRIGATION

D.P. Rao and K.S. Rao

Solar Energy, v.18, no.5, 1976, p.405-411

Abstract—Two types of solar water pumps for lift irrigation have been developed and tested. In this paper the thermodynamic and design aspects of the pumps are discussed. The pumps have no moving parts except for the check valves. No auxilliary power source or technical skill is required to run the pumps making both designs extremely suitable for rural lift irrigation. The running cost is nil except for the occasional use of an inexpensive organic fluid. Feasibility studies of the pumps indicate that they are economically viable and are within the means of an Indian farmer.

77A49027 ISSUE 23 PAGE 4007 CATEGORY 44  
76/00/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Salt requirement and stability of solar ponds

AUTH: A/NIELSEN, C. E.; B/RABL, A. PAA: A/(Ohio State University, Columbus, Ohio); B/(Argonne National Laboratory, Argonne, Ill.)

In: Sharing the sun: Solar technology in the seventies; Proceedings of the Joint Conference, Winnipeg, Canada, August 15-20, 1976. Volume 5. (A77-48910 23-44) Cape Canaveral, Fla., International Solar Energy Society, 1976, p. 183-187.

MAJS: /\*BOUNDARY LAYER STABILITY/\*ENERGY TECHNOLOGY/\* SALINITY/\*SOLAR PONDS (HEAT STORAGE)

MINS: / CLEAN ENERGY/ CONVECTIVE HEAT TRANSFER/ COST REDUCTION/ INSOLATION

ABA: G.R.

ABS: The cost involved in the establishment of solar-pond systems for the storage of solar energy is largely determined by the cost of the salt. The stability conditions for the solar pond are considered with the objective to minimize the salt requirements. A framework is presented for analyzing the stability of the boundary between a convective and a nonconvective layer of a solar pond. Attention is also given to approaches for preserving the required salinity gradient against diffusion.

TJ

810

.S48

1976

v.10

Business, commercial, poster session, miscellaneous : joint conference, American Section, International Solar Energy Society and Solar Energy Society of Canada, inc., August 15-20, 1976, Winnipeg / edi-

UTILIZATION OF URBAN ROOFTOPS FOR FOOD PRODUCTION

218

DEVELOPMENT AND TESTING OF A VARIETY OF SOLAR COOKERS

219

SOLAR HEAT FOR GRAIN DRYING

183

77A49028 ISSUE 23 PAGE 4007 CATEGORY 44 CNT#:  
AT(45-1)-1830 76/00/00 15 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Solar pond stability experiments  
AUTH: A/LESHUK, J. P.; B/ZAWORSKI, R. J.; C/STYRI, D. L.;  
D/HARLING, C. K. PAA, B/(Oregon State University,  
Corvallis, Ore.); D/(Battelle Pacific Northwest  
Laboratories, Richland, Wash.)

In: Sharing the sun: Solar technology in the  
seventies: Proceedings of the Joint Conference,  
Winnipeg, Canada, August 15-20, 1976. Volume 5,  
(477-489) 23-44) Cape Canaveral, Fla.: International  
Solar Energy Society, 1976, p. 153-162.

MAUS: /HEAT STORAGE/SOLAR COLLECTORS/SOLAR PONDS (HEAT  
STORAGE)/SYSTEMS STABILITY/THERMAL STABILITY  
WINS: /DATA REDUCTION/ENERGY TECHNOLOGY/FAILURE MODES/  
MATHEMATICAL MODELS/PERFORMANCE PREDICTION/  
TEMPERATURE GRADIENTS

ABA: V.L.

ABS: Nonconvecting salt pond solar collector/storage  
systems are studied with attention to the long term  
stability of salinity gradients. The results of a year-  
long experimental investigation are reported with  
conclusions drawn from partial data reduction. Despite  
limitations of model systems, which are discussed,  
favorable observations about the stability of these  
thermohaline systems were obtained. A maximum bottom  
temperature of 76 C and stable temperature gradients  
ranging from 150 - 300 C/meter were detected. Slow top  
and bottom mixing layer growth was the only failure  
mode noted despite attempts to introduce instabilities  
at intermediate levels. It is thought that normal  
energy extraction and evaporation make-up methods  
might provide a stabilizing influence.

#### GRAIN DRYING IN STATION BINS WITH SOLAR HEATED AIR

G. Roa and I. C. Macedo

Solar Energy, v.18, no.5, 1976, p.445-449

Abstract—In Brazil, most of the grains are dried naturally in the fields or on concrete floors; recently continuous type  
of driers have been used extensively. However, the drying of grains in silos has not been adopted yet, in spite of the  
good ambient conditions. This paper presents results from the drying of 600 kg of "carioca" dry beans in a round bin  
with a perforated floor, using solar energy as the only supplemental heat source. The performance of the flat plate  
collectors is analysed; the drying data is analysed with the basic equations of transfer complemented with newly  
proposed empirical equations describing the thin layer drying and equilibrium data. The agreement between  
experimental and theoretical results is quite satisfactory, justifying the utilization of this model for simulation  
studies. The net effect of the solar energy was to accelerate by about 4 times the drying rates of grains in the top of  
the bin; the use of average inlet conditions, as compared to the inlet varying conditions, was also satisfactory after  
26 hr of drying over a period of three days. Although the overall efficiency of the collecting system was good, the  
design of ducting, the bin and collector materials and geometry can be improved.

TJ  
810  
.S48  
1976  
v.1

International and U.S. programs, solar flux :  
joint conference, American Section, Inter-  
national Solar Energy Society and Solar En-  
ergy Society of Canada, inc., August 15-20,  
1976, Winnipeg / editor, K.W. Dör. -- Cape  
Canaveral, Fla. : American Section of the  
International Solar Energy Society, c1976.  
x, 388 p. : ill. ; 28 cm. -- (Sharing the  
sun ; v. 1)

ERDA SOLAR THERMAL ENERGY PROGRAM FOR 176  
INDUSTRIAL PROCESS HEAT

T.J  
7413  
.L8

Lucas, Ted

How to build a solar heater : a  
complete guide to building and buying ;  
solar panels, water heaters, pool  
heaters, barbecues, and power plants /  
Ted Lucas. Pasadena, [Calif.] : Ward  
Ritchie Press, 1975.

xi, 236 p. : ill. ; 22 cm.

PAGE

8. Heating Your Swimming Pool

141

CH-150,008

1974

A SOLAR POWERED OBSERVATION PLATFORM. J.F.W. Parry.  
(Tech. Rept). July 1974. 13p.

R and O Associates,

RDA-TR-4300-008

Santa Monica, Calif.

Contract N00033-74-C-0090

Aircraft, Solar-powered

IX. WIND . . . . .	876
A. General . . . . .	877
B. Resources, Utilization, and Engineering . . . . .	881
C. Vertical-Axis Windmills . . . . .	946
D. Transportation Applications . . . . .	962



## WIND - GENERAL

N79 31838# National Technical Information Service, Springfield, Va.

**WIND POWER, VOLUME 2. CITATIONS FROM THE ENGINEERING INDEX DATA BASE Progress Report, 1978 - Apr. 1979**

Audrey S. Hundemann Jun 1979 131 p Supersedes NTIS/PS-78/0417; NTIS/PS-77/0400; NTIS/PS-76/0359 (NTIS/PS-79/0536/7; NTIS/PS-78/0417; NTIS/PS-77/0400; NTIS/PS-76/0359) Avail. NTIS HC \$28.00/MF \$28.00 CSCI 10B

Windmill and wind power feasibility, use, and engineering are discussed in these citations of world-wide research. Abstracts primarily cover the use of wind power for electric power generation

and wind turbine design and performance. General studies dealing with the use of wind power in developing countries and comparative analyses of wind power and alternative energy sources are included, as are studies on energy storage systems. This updated bibliography contains 125 abstracts, 113 of which are new entries to the previous edition. GRA

### ELECTRICITY GENERATION FROM JET-STREAM WINDS.

C. A. J. Fletcher and B. W. Roberts.

Journal of Energy, vol 3, no 4, July-August 1979, p. 0. 241-249.

The feasibility of generating electricity from jet-stream winds has been investigated. Analysis of published meteorological data indicates that annual average power densities approaching  $20 \text{ kW/m}^2$  are available in the jet-stream altitudes over the complete west-east extent of Australia at a latitude of about  $30^\circ \text{ S}$ . Computer-based optimization studies indicate that a 100 MW power station based on tethered aerodynamic generating platforms located at a jet-stream altitude would generate electricity at capital and operating costs that are competitive with other methods of electricity generation. The design of the tethered aerodynamic generating platform requires a high lift-to-weight ratio platform housing high power-to-weight ratio diffuser-augmented wind turbines and tethered by a high strength-to-weight ratio cable. Key design parameters include the turbine power coefficient and power-drag coefficient, the rated speed, and the stall speed. The required turbine area is determined primarily by the power coefficient and the rated speed. The cable weight depends directly on the drag associated with the maximum (rated) power generation which follows from the choice of rated speed. The wing area of the aerodynamic platform is fixed usually by the stall speed.

A REVIEW OF THE U. S. WIND ENERGY PROGRAMME. H. H. Lipman.

Wind Engineering, vol 3, no 2, 1979, p. 75-107.

*The review of the U.S. wind energy programme that follows was carried out under a contract from the U.K. Department of Energy. We are grateful for their permission to publish the work.*

*Although our review was completed in September 1978 most of what is said is relevant to today. Most R & D and building projects take several years to complete and not too much changes in 1 year. It is worth noting that U.S. funding for wind energy has now reached a level of approximately 60 million dollars per annum.*

A79 46526 Workshop on Economic and Operational Requirements and Status of Large Scale Wind Systems, Monterey, Calif., March 28-30, 1979, Proceedings. Workshop sponsored by the U.S. Department of Energy and Electric Power Research Institute. Edited by E. F. Clark and F. de Winter (Altas Corp., Santa Cruz, Calif.), Santa Cruz, Calif., Altas Corp., 1979. 465 p. (For individual items see A79 46527 to A79 46548)

The work deals with analytic and experimental studies on the integration of wind generation into electric utility networks. Overviews of major wind program elements are included, covering activities in wind turbine generators (WTG) hardware design and development, wind energy resource assessment and environmental issue assessment. The paper covers the following sessions: (1) wind energy technology overview; (2) wind generation value in electric utility systems; (3) large wind turbine generator operation and status, and (4) network interaction analyses. Consideration is given to economic requirements and value analysis, and operational experience and status. V.T.



**N80-14543#** Department of Energy, Washington, D. C.  
**COMMERCIALIZATION STRATEGY REPORT FOR SMALL WIND SYSTEMS**

Louis V. Divone, R. Blaunstein, J. Gros, A. K. Ingberman, W. L. R. Rice, and S. J. Taylor [1979] 46 p refs  
(TID-28844-Draft) Avail: NTIS HC A03/MF A01

The commercial readiness of small wind systems is addressed. Barriers to be overcome before this technology is ready to be used commercially are cited and possible actions that might be considered to remove specific barriers are identified. The full implications of the various proposed actions have not been fully developed and many actions listed undoubtedly have substantial problems associated with them.

DOE

**N80-14544#** Department of Energy, Washington, D. C.  
**COMMERCIALIZATION STRATEGY REPORT FOR LARGE WIND SYSTEMS**

Louis V. Divone, R. Blaunstein, J. Gros, A. K. Ingberman, W. L. R. Rice, and S. J. Taylor [1979] 41 p

(TID-28843-Draft) Avail: NTIS HC A03/MF A01

The commercialization of wind turbines is analyzed concerning technical readiness, market and economic aspects, environmental impacts, institutional acceptance, benefit analysis, and commercialization development strategy.

DOE

**CAN WE AFFORD NOT TO DEVELOP THE HIGH TOWER WINDMILL NOW?** Howard E. Wahrenbrock.

Public Utilities, Fortnightly, vol 104, no 7, September 27, 1979. p. 42-47.

*The Federal Power Commission investigation in the 1940's of the potentialities of wind power for electric utility use was conducted by Percy H. Thomas. The author of this article had previously presented Thomas as an expert witness on transmission of electric energy through an interstate power pool in one of the earliest FPC jurisdictional cases, and they frequently discussed the subject of the wind power investigation as it progressed. This article is a distillation of a longer account by the author of what he discovered when he recently sought to ascertain what had happened to Thomas' work after Thomas' death in 1957.*

**N80-11602#** Midwest Research Inst., Kansas City, Mo.  
**STATUS OF INFORMATION FOR CONSUMERS OF SMALL WIND ENERGY SYSTEMS**

P. Weiss Feb 1979 19 p refs Presented at the Symp. on Commercialization of Solar and Conserv. Technol., Miami Beach, Fla., 11 Dec 1978

(Contract EG-77-C-01-4042)

(SERI/TP-51-158. Conf-781235-3) Avail: NTIS HC A02/MF A01

Research efforts, existing information sources, and ongoing work to improve data necessary for potential consumers of small wind energy conversion systems are presented.

DOE

**N79-31837#** National Technical Information Service, Springfield, Va

**WIND POWER, VOLUME 1. CITATIONS FROM THE ENGINEERING INDEX DATA BASE Progress Report, 1970 - 1977**

Audrey S. Hundemann Jun 1979 225 p

(NTIS/PS-79/0535/9) Avail: NTIS HC \$28.00/MF \$28.00 CSCL 10B

This bibliography contains 210 citations on windmill and wind power feasibility, use, and engineering. The use of wind power for electric power generation and wind turbine design and performance is reported. The use of wind power in developing countries and comparative analyses of wind power and alternative energy sources are included, as are studies on energy storage systems.

GRA

**N79-31836#** National Technical Information Service, Springfield, Va

**WIND POWER, VOLUME 2. CITATIONS FROM THE NTIS DATA BASE Progress Report, 1977 - Apr. 1979**

Audrey S. Hundemann Jun 1979 282 p Supersedes NTIS/PS-78/0416, NTIS/PS-77/0399, NTIS/PS-76/0358, NTIS/PS-75/348, COM-74-11103

(NTIS/PS-79/0534/2, NTIS/PS-78/0416, NTIS/PS-77/0399, NTIS/PS-76/0358, NTIS/PS-75/348, COM-74-11103) Avail: NTIS HC \$28.00/MF \$28.00 CSCL 10B

This bibliography contains 276 citations on the feasibility, use, and engineering aspects of wind power and windmills. The use of wind power for electric power generation and wind turbine design and performance is examined. Comparative analyses of wind power and alternative energy sources are included, as are energy storage devices which can be used in these systems.

GRA

TK  
1541  
.W56

**Wind power : recent developments / edited  
by D. J. De Renzo. -- Park Ridge, N.J. :  
Noyes Data Corp., 1979.**  
x, 347 p. : ill. ; 24 cm. -- (Energy  
technology review ; no. 46)  
Includes bibliographical references  
and index.

ISBN 0-815507-59-3

The work presents the most important developments which have  
occurred in wind power technology in the U.S. in the last five years.  
New useful devices and constructions are interpreted and explained  
by actual case histories, which provide a sound background for  
action toward combating the energy shortage. Special attention is  
given to rotor development, wind turbines, and the application of  
wind power to electric utilities. C.F.W.

**Energy From the Wind: Annotated  
Bibliography**  
Barbara L. Burke and Robert N.  
Merorey  
Publications Dept.  
Engineering Research Center  
Colorado State University  
Foothills Campus  
Fort Collins, CO 80523  
\$15.00

This bibliography contains 1900 ref-  
erences, with annotations, on wind  
power. Organized by year of publica-  
tion and cross referenced by author.  
Of interest are the 1890 to 1920 ref-  
erences. -d.m.

A79-52951 Limits to wind-power. R. W. B. Best  
(EURATOM and Stichting voor Fundamenteel Onderzoek der  
Materie, Instituut voor Plasmafysica, Jutphaas, Netherlands). *Energy  
Conversion*, vol. 19, no. 2, 1979, p. 71, 72. Research supported by  
the Nederlandse Organisatie voor Zuiver-Wetenschappelijk Onder-  
zoek and EURATOM.

Simple formulas are given for the change in wind-power,  
frictional stress and vertical energy transport in the atmospheric  
boundary layer, caused by the erection of windmill arrays. The limit  
to wind-power conversion appears to be around 1 W/sq m of terrain  
in both coastal and inland areas. (Author)

AGARDograph No. 243  
Advisory Group for Aerospace Research and  
Development, NATO  
**FLUID DYNAMIC ASPECTS OF WIND ENERGY  
CONVERSION**  
by O. de Vries  
Published July 1979  
150 pages

A review is made of the fluid dynamic aspects of wind  
energy conversion. A short survey of the total frame-  
work of wind energy conversion is given to bring the  
fluid dynamics aspect in its proper dimensions. Next,  
the several wind concentrator concepts are discussed,  
while the main body of the report is formed by a dis-  
cussion of the theory of wind-driven turbines, including  
both the horizontal-axis and the vertical-axis turbines.

P.T.O.

AGARD-AG-243

Fluid dynamics  
Wind power generation  
Windmills  
Wind (meteorology)  
Turbines  
Turbulence  
Wakes

N79-33804/ Florida Univ., Gainesville.  
**PROCEEDINGS OF THE U. S. NATIONAL CONFERENCE  
ON WIND ENGINEERING RESEARCH, 3RD**  
Bernard M. Leadon, ed. 1978 538 p refs Conf. held at  
Gainesville, Fla., 28 Feb. - 1 Mar. 1978  
(Grant NSF PFR-77-10170)  
(PB-296335/3; NSF/RA-780466) Avail: NTIS  
/HC A23/MF A01 CSCL 13B

An exchange of information between engineers, architects,  
and scientists on wind-engineering problems and research is  
documented. The objectives set forth were: (1) to provide an  
opportunity for presentation of research activities and preliminary  
research findings; (2) to simulate discussion and interaction  
between research workers active in complementary subject areas;  
(3) to develop lines of communication and cooperation between  
research engineers, scientists and practicing engineers and  
architects; and (4) to identify subject areas that need more  
intensive research. Information on wind associated with severe  
storms (tornadoes), thunderstorm downbursts, hurricanes and  
downslope winds is presented. GRA

N79-30771/ Market Facts, Inc., Washington, D. C.  
**SMALL WIND ENERGY: FOCUS GROUP RESULTS**  
1978 43 p  
(Contract EV-78-C-01-6458)  
(DOE/TIC-10018) Avail: NTIS HC A03/MF A01

The potential for commercialization of small wind energy  
was evaluated. The barriers to development of this resource were  
determined. Actions required by the Federal Government to  
promote commercialization were also determined. DOE

**A79-40101** International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Symposium sponsored by the British Hydromechanics Research Association. Edited by H. S. Stephens (British Hydromechanics Research Association, Cranfield, Beds., England). Cranfield, Beds., England, British Hydromechanics Research Association, 1978. 447 p. \$45.26. (For individual items see A79-40102 to A79-40133)

National wind energy programs in the Netherlands, Sweden, the USA, Japan, and Tanzania, and wind characteristics programs are presented. Consideration is given to the aeroelastic stability and behavior of wind rotors, theoretical and experimental data, and new concepts, such as a variable geometry vertical axis windmill and a flexible blade windmill. Attention is paid to such systems aspects as an economic model to establish the value of the Wind Energy Conversion Systems (WECS) to a utility system, and the regulation of an electricity supply system including wind energy generators.

V.T.

**A79-15870 #** Wind energy conversion. A. A. Fejer (Illinois Institute of Technology, Chicago, Ill.). *Institute of Gas Technology, Energy from the Sun Symposium, Chicago, Ill., Apr. 3-7, 1978*, Paper. 26 p. 18 refs.

P 399

Effective utilization of wind energy requires systematic studies of the sites available for the location of wind energy conversion systems and careful evaluation of the type and size of machines to be used. The present paper describes an approach currently in use for the siting of wind generators. It describes also the aerodynamic features of various types of wind machines and indicates the present status of development and prospects of horizontal axis propeller type and vertical axis Darreius turbines.

(Author)

**N78-27600** National Technical Information Service, Springfield, Va.

**WIND POWER. VOLUME 1. CITATIONS FROM THE NTIS DATA BASE Progress Report, 1964 - 1976**

Audrey S. Hundemann May 1978 206 p  
(NTIS/PS-78/0415/6) Avail NTIS HC \$28.00/MF \$28.00 CSCL 10B

The feasibility, use, and engineering aspects of wind power and windmills are discussed in these citations of Federally-funded research reports. Abstracts primarily cover the use of wind power for electric power generation and wind turbine design and performance. General studies dealing with comparative analysis of wind power and alternative energy sources are included, as are energy storage devices which can be used in these systems.

GRA

**Wind Power (Citations from the Engineering Index Data Base).**

Audrey S. Hundemann.

National Technical Information Service, Springfield, Va.  
May 78, 238p

NTIS/PS-78/0417/2WE Price code: PC N01/MF N01

Windmill and wind power feasibility, use, and engineering are discussed in these citations of worldwide research. Abstracts primarily cover the use of wind power for electric power generation and wind turbine design and performance. General studies dealing with the use of wind power in developing countries and comparative analyses of wind power and alternative energy sources are included, as are studies on energy storage systems. (This updated bibliography contains 231 abstracts, 81 of which are new entries to the previous edition.)

## WIND - RESOURCES, UTILIZATION, AND ENGINEERING

QC Symposium on Turbulence, Diffusion, and Air  
880.4 Pollution, 4th, Reno, Nevada, 1979.  
.T8 Fourth Symposium on Turbulence, Dif-  
S9 fusion and Air Pollution, January 15-18,  
1979, Reno, Nevada : preprints / American  
Meteorological Society. -- Boston ; AMS,  
c1978.

p.160-176 xv, 676 p. : ill.  
Includes bibliographies and index.  
1. Air pollution--Congresses. 2. Wind

### SESSION 3B: WIND ENERGY STUDIES

CHAIRMAN: Steven R. Hanna, Atmospheric Turbulence and Diffusion Lab./NOAA,  
Oak Ridge, Tenn.

- 3.7 PROGRAM OVERVIEW FOR THE WIND CHARACTERISTICS PROGRAM ELEMENT OF THE UNITED STATES FEDERAL WIND ENERGY PROGRAM. Larry L. Wendell and Charles E. Elderkin, Battelle Pacific Northwest Labs., Richland, Wash.
- 3.8 A COMPARISON OF TECHNIQUES FOR ESTIMATING WIND CHARACTERISTICS. David S. Renné, Battelle Pacific Northwest Labs., Richland, Wash.
- 3.9 ESTIMATION OF WIND CHARACTERISTICS AT POTENTIAL WIND ENERGY CONVERSION SITES. C. M. Bhumralkar, F. L. Ludwig, and R. L. Mancuso, SRI International, Menlo Park, Calif.
- 3.10 THE EVALUATION OF NUMERICAL MODELS FOR THE SITING OF WIND ENERGY MACHINES. William T. Pennell, Battelle Pacific Northwest Labs., Richland, Wash.

## *Catch the Wind*

by Landt Dennis  
photographs by Lisl Dennis

*Catch the Wind* is an absorbing look at how windmills and windpower were used in the past (spiced with some fascinating anecdotes about the foibles and eccentricities of the men who have "harnessed" the wind throughout history) and the problems and possibilities of windpower making a "come-back" today. A helpful index and bibliography are included, as well as sources of information about building windmills and wind generators.

160

A79-48068 Wind and solar energies in the tornado type wind energy system. J.-M. Chen (National Tsing Hua University, Hsinchu, Nationalist China). *International Journal of Heat and Mass Transfer*, vol. 22, July 1979, p. 1159-1161. 12 refs.

- \* The results of an analytical model of buoyancy-driven vortices about a solar line heat source in a tornado type wind energy system are examined. The set of ordinary differential equations were reduced to eight first-order differential equations by the Runge-Kutta direct integration method. New values of the missing initial conditions for adjoint equations were solved using the shooting iterative method. The dimensionless circulation and potential temperature, tangential and vertical velocities as well as pressure distribution are evaluated and their graphs are drawn. Conclusions show that the heat from the solar collector affects the tangential velocity and pressure drop at the vortex center axis increases as the strength of the line heat source increases. C.F.W.

167



TK  
2896  
.155  
1979

Intersociety Energy Conversion Engineering  
Conference, 14th, Boston, 1979.  
Proceedings of the 14th Intersociety  
Energy Conversion Engineering Conference,  
Boston, Massachusetts, August 5-10, 1979.  
-- Washington, D. C. : American Chemical  
Society, c1979.

799069  
**Design and Performance of Bicycle Wind  
Turbine Rotors, W.M. Mansour and M.H.  
Hirata** ..... 308

799070  
**The Application of Wind Energy to a System  
with an Inherent Energy Storage Medium,  
T. Kobylarz and A. Al-Shehri** ..... 312

799071  
**Assessment of Wind Energy Systems in a  
Utility Framework, S.L. Macklis and J.L.  
Ophinger** ..... 319

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**NASA TP-1389 Windmills - Resources 1979**

**SUMMARY OF ATMOSPHERIC WIND DESIGN CRITERIA  
FOR WIND ENERGY CONVERSION SYSTEM DEVELOPMENT.**

**Walter Frost, Tenn. Univ. Space Inst. and  
Robert E. Turner, NREPC. Jan. 1979. 54p.**

This report presents basic design values of significant wind criteria, in graphical  
format, for use in the design and development of wind turbine generators for energy  
research. It is a condensed version of portions of the "Engineering Handbook on the  
Atmospheric Environmental Guidelines for Use in Wind Turbine Generator Development,"  
NASA TP-1359, 1978.

**A80-23534** Describing wind data D. T. Swift-Hook  
(Central Electricity Generating Board, Applied Physics Div., Leather-  
head, Surrey, England). *Wind Engineering*, vol. 3, no. 3, 1979, p.  
167-186.

When assessing a potential wind-power site for which wind data  
are available, it is important to know for what fraction of the time  
wind of any given speed is available. It is noted that wind data are  
usually presented as the amount of time various wind speeds are  
exceeded, i.e. as cumulative probabilities. The distributions are  
usually (half-) bell-shaped indicating that, for most of the time, the  
wind is in some preferred range that can be specified in terms of its  
'upper' and 'lower' velocities. It follows that many sets of data fit  
Weibull distribution curves; the parameter alpha adjusts the shape of  
the bell and can be found by various methods, including the slope of  
a Weibull plot, from 'upper' and 'lower' or 90% and 10% velocities,  
from the slope along the straightest part of the curve, or by  
calculation using individual points. It is concluded that a wide range  
of wind speeds can be summarized by specifying two parameters: the  
standard wind speed and the shape factor. L.M.

**A80-23535** Wind energy research and development at  
Lincoln. R. E. Chilcott (Lincoln College, Canterbury, New Zealand).  
*Wind Engineering*, vol. 3, no. 3, 1979, p. 187-196. 14 refs.

Wind and energy research and development work undertaken at  
Lincoln College, New Zealand, and covering such activities as  
wind-energy surveying and resource assessment, wind-environment  
amelioration and wind-power utilization, is discussed. Results show  
that in order to provide reliable air generator systems techniques  
developed for aircraft, helicopters and wind-sensitive structures have  
to be used, for example, helicopter blades, coupled to a hydraulic  
variable-pitch agricultural-aircraft-type propeller hub. Provided that  
these methods are applied to produce economic systems, (estimated  
at 10 cents/KWh) wind power can make a small but significant  
contribution to electricity supplies. The impact of wind turbines on  
the environment remains to be seen. With rising oil prices the  
increased use of agricultural and horticultural shelter and the fairing  
of road transport vehicles to reduce fuel consumption are expected  
as immediate impacts, associated with wind-environment ameliora-  
tion. L.M.

**N79-27668/** Sandia Labs., Albuquerque, N. Mex.  
**ANALYSIS OF THE POTENTIAL OF WIND ENERGY  
CONVERSION SYSTEMS**

Jack W. Reed 1979 24 p refs Presented at Conf. on Energy  
Alternatives, Honolulu, 9 Jan. 1979  
(Contract EY-76-C-04-0789)  
(SAND-78-2099C; Conf-790114-1) Avail: NTIS  
HC A02/MF A01

The flow of solar energy and wind was reviewed. The time  
and space distribution of useful wind power are described. Some  
of the modern machinery that was conceived to capture wind  
energy was considered. Some limitations to practical wind  
energy extraction are presented. Available and projected wind  
power hardware systems are summarized. DOE

# ELECTROMAGNETIC INTERFERENCE TO TELEVISION RECEPTION CAUSED BY HORIZONTAL AXIS WINDMILLS.

Dipak L. Sengupta, and Thomas B. A. Senior.

Proceedings of the IEEE. vol 67, no 8, August 1979. p. 1133-1142.

**Abstract**—Electromagnetic interference to television (TV) reception produced by horizontal axis wind turbine generators or windmills has been identified and quantified by comprehensive theoretical and experimental studies. It is found that the rotating blades of a windmill can produce pulse amplitude modulation (PAM) of the total signal received, and that for an antenna so located as to pick up the specular or forward scattering off the blades, this extraneous modulation can distort the video portion of a TV signal reproduction in the vicinity of the windmill. The distortion is worst at the higher frequencies, and therefore, poses more of a problem at UHF than VHF. Based on laboratory studies as well as on-site measurements, a modulation level has been established at which the video interference is judged "acceptable," and this threshold of interference is substantially independent of the ambient signal strength. A theory has been developed to compute the interference region about a windmill for any given TV transmitter, and the results are in good agreement with those obtained from on-site measurements with an operational windmill.

LIMITS TO WIND POWER UTILIZATION, by M. R. Gustavson  
Science, vol. 204, no. 4383, April 1979, p.13-17.

**Summary.** As wind energy receives increasing attention it is important to understand the noneconomic factors limiting the total power that can be extracted from the wind. These factors are examined here with a macroscopic approach. An upper global limit of  $1.3 \times 10^{14}$  watts is arrived at with a sublimit of  $2 \times 10^{12}$  watts for the continental United States. Some general conclusions are also reached regarding the sites that would have to be utilized to achieve these levels. Even within these limits, wind energy is seen to offer a potential far larger than many other self-renewing energy sources.

ENERGY FROM HUMID AIR, by L. Icerman.  
Energy, vol. 4, no. 1, Feb. 1979, p.132-133.

Energy extraction from humid air is yet another novel, indirect application of solar energy that is currently being investigated.<sup>1,2</sup> The latent heat of vaporization, which is supplied by solar energy, may be released to the surrounding air when the water vapor in humid air is condensed. Like so many other solar-based technologies, the energy density is relatively small but the magnitude of the total potential resource is very large.

# AN ECONOMIC EVALUATION OF SMALL-SCALE WIND-POWERED ELECTRIC GENERATION SYSTEMS.

Transactions of the ASME, vol 101, no 2, April 1979, p. 213-216. Journal of Engineering for Power

*Presented is an economic evaluation of several commercial wind-powered electric generation systems of the type which could be used by an individual homeowner. A system includes a wind plant, tower, storage battery, and dc to ac inverter. The analysis considered a total of 12 different system configurations. The evaluation of energy output is based on wind speed data for several locations in the state of Montana. The analysis can be extended to other locations on the basis of mean annual wind speed.*

*The results of the evaluation indicate that some of the "home built" systems are competitive economically at the present time in some "windy" locations. None of the systems which are economic could individually supply the entire power requirement for a single-family dwelling.*

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1979  
Intersociety Energy Conversion Engineering Conference, 14th, Boston, 1979.  
Proceedings of the 14th Intersociety Energy Conversion Engineering Conference, Boston, Massachusetts, August 5-10, 1979.  
-- Washington, D. C. : American Chemical Society, c1979.  
2 v. (xviii, 2078, 294 p.) : ill.  
"IEEE 79CH1477-9 Energy."  
Includes bibliographical references and

799072  
Wind Tunnel Tests of a 1/30 Scale Model of a 3.5 Megawatt Wind Turbine, H.S. Wainauski 2050

A79-43576 Cretan windmills. M. T. Kanaki and S. D. Probert (Cranfield Institute of Technology, Cranfield, Beds., England). *Applied Energy*, vol. 5, July 1979, p. 215-222. 23 refs.  
Tip speed/wind speed ratio calculations are presented for Cretan-type windmills. The design of Cretan windmills incorporates a near-horizontal shaft with radial spars carrying triangular canvas sails whose bases are towards the circumference of the mill. The edge of each sail is attached to a spar, with the opposite corner secured to an adjacent spar by a cord. The spars are stayed together at the tips and the entire structure is supported by wires connecting the forward extension of the shaft to the outer tips of the spars. These systems are particularly efficient at low wind speeds (less than 5 m/sec) and are easily constructed. They offer a potentially useful source of energy for developing countries. C.K.D.



**RENEWABLE ENERGY PROSPECTS. (Special Issue).  
(Proceedings of a Conference on Non-Fossil Fuel  
and Non-Nuclear Fuel Energy Strategies.  
Held in Honolulu, Hawaii, Jan. 9-12, 1979.  
Sponsored by the United Nations University at  
Tokyo, Japan). Wilfrid Bach, et al, eds.**

Reed, J. W.: An analysis of the potential of wind energy conversion systems . . . 811

**Abstract** Wind Energy Conversion Systems (WECS) are solar systems because the sun drives the atmospheric circulation. About 20 TW of wind energy flows poleward annually, over land in temperate latitudes, in the 500 m deep atmospheric boundary layer. An average 500 GW of electricity could be generated by massive exploitation of the U.S. Great Plains wind field.

There are, however, large fluctuations in available wind power. There are frequent 20% variations in annual supply; annual periodicity brings most wind power during the spring; there are diurnal cycles; and there is a diurnal cycle. Gusts and turbulence also require filtering to meet normal power requirements. Several schemes are evolving to tame this erratic wind power supply.

Modern technology is refining horizontal-axis turbines of a wide size range. Progress is also being made toward producing an economical vertical-axis turbine. Standards for turbine performance evaluation and installation site selection are now being developed. Yet it will be a few years before proven systems can significantly affect national energy supplies.

Eventually, mass-produced WECS may cost \$1000 per installed, rated kW, but the wind does not often flow at turbine-rated speed. With some storage or filtering, problems with wind variability may be overcome. Then WECS electricity production may be as economical as other electric generators. No serious hazards or environmental impacts should slow WECS development.

A79-47652 # Computer simulation and design of the control system for a wind turbine generator. H. Sambar, V. Pavelic, and R. J. Warner (Wisconsin, University, Milwaukee, Wis.). *American Society of Mechanical Engineers, Design Engineering Conference and Show, Chicago, Ill., May 7-10, 1979, Paper 79-DE-9*. 5 p. 8 refs.

The wind turbine generator proposed is a horizontal axis machine with three blades operating downwind. A hydraulic system actuates mechanical linkages to control blade pitch during operation. The blade pitch control concept provides active control of rotor rpm above the rated wind speed and during no load condition. The lowering of blade and tower loads while providing the capability for well tuned rotor control are its primary features. A hydraulic system, designed to control the pitch of the blades of a wind turbine generator, is simulated on the digital computer using the Runge-Kutta method. The control system subroutine is coupled with the aerodynamic subroutines of the blades to represent the model for the wind turbine generator. The response of the simulated wind turbine to a real wind case is shown to agree with the desired response.

(Author)

A79-38178 # The use of a complex terrain wind model for the siting and design of wind generators. M. A. Yocke, J. Johnson, and M. K. Liu (Systems Applications, Inc., San Rafael, Calif.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0971*. 7 p.

The questions arising when wind power is under consideration for the generation of electricity, such as how much annual wind energy can be expected and how the wind is distributed, are discussed showing the need for a knowledge of wind speeds and directions. A wind model based on the three-dimensional mass continuity equation, with the appropriate physical processes parameterized is analyzed. Derivation of the equation is given, noting that the model considers perturbations such as dimensions of the flow due to topographic effects, and power law wind profile due to boundary effects. The model's performance was assessed by applying it to Phoenix, Arizona and Los Angeles, California. M.E.P.

**A LOW LEVEL WIND MEASUREMENT TECHNIQUE OF WIND  
TURBINE GENERATOR SITING**

Robert W. Baker, Raymond L. Whitney and E. Wendell Hewson

Wind Engineering, vol. 3, no. 2, 1979, pp. 107-114.

*Large wind turbine generators to be constructed soon will have rotors as great as 100 m in diameter. Strong and persistent winds are needed if these aerogenerators are to be cost effective. Preliminary site surveys in mountainous terrain to locate such large machines require inexpensive, portable and reasonably accurate methods for measuring winds at heights up to 100 m or more above the ground. Of the various methods available, the recently developed Tethered Aerodynamically Lifting Anemometer (TALA) has been tested and found to be the most satisfactory. The TALA system consists of a kite with tail, tethering line, reel, and either a spring scale for direct measurements of the line tension or a recording strain gauge. Atmospheric density corrections are applied to the basic wind tunnel calibration.*

*The TALA system has been used for nearly two years with encouraging results. We have conducted our own checks on the calibration of the system by flying the TALA kite as near as possible to tower-mounted anemometers at heights ranging from 17 to 100 m. Errors ranged from 1 to 3 percent or up to 5 percent if the error in tower anemometers is allowed for. Using the strain gauge and analog recorder the error at a height of 100 m was within the 2 percent claimed by the manufacturer. The lack of systematic errors over this height range suggests that wind drag on the line of varying lengths does not introduce significant error. The equipment is relatively inexpensive and portable. With a small lifting balloon filled with helium it can be flown in very light surface winds to a level where the wind is at least  $4 \text{ m s}^{-1}$ , the threshold of the TALA system. Maximum wind speed is given as  $40 \text{ m s}^{-1}$ . Although present use of the TALA system is for large wind turbine generator siting in mountainous terrain, it should be equally effective for air pollution investigations.*

A WINDMILL'S THEORETICAL MAXIMUM EXTRACTION OF POWER FROM THE WIND. David Rittenhouse Ingils.

American Journal of Physics, vol 47, no 5, May 1979, 416-420.

The fraction of the kinetic energy of the wind impinging on its area, that a wind turbine can convert to useful power, has been shown by Betz in an idealized laminar-flow model to have an upper limit of 16/27 or 59%. The limit is here simply rederived and it is shown how deviations from the idealized model, involving rotational kinetic energy of the downwind stream and turbulent mixing from outside the boundaries of the idealized stream, can either increase or decrease the power available. The limit is thus not a strict upper limit in practice.

A79-41948 Optimal value of the rated speed of a wind generator. M. Diesendorf (Commonwealth Scientific and Industrial Research Organization, Div. of Mathematics and Statistics, Canberra, Australia) and G. Fulford. *Wind Engineering*, vol. 3, no. 1, 1979, p. 62-68. 10 refs.

In this paper, South Australian windspeed data are modelled with the Weibull distribution, while the response (i.e. power density output) of a wind generator, between its starting speed and rated speed, is chosen to be the sum of a cubic function of windspeed and a constant term. An expression is derived for the value of the parameter which yields the maximum of the annual energy production. In the particular case when the two-parameter Weibull distribution reduces to the one-parameter Rayleigh distribution, which is a fairly good fit to the data studied, the values of the parameters of interest are (rated speed/mean windspeed) max = 2.04 and (mean of the cubed windspeed/cube of the mean windspeed) = 1.9. Attention is drawn to the important role of the starting speed of the wind generator, which determines, together with the rated speed, whether there is a maximum annual energy production and, if so, where in parameter space the maximum is to be found. V.T.

## COST-EFFECTIVENESS OF THE VORTEX-AUGMENTED WIND TURBINE.

Ozer Igra.

Energy, vol 4, no 1, February 1979, p. 119-130.

**Abstract**—Cost estimates for the conventional, horizontal-axis, wind turbine and for the vortex-augmented wind turbine are presented. For the latter, the vortex is generated by an appropriate delta wing. It is shown that the vortex-augmented wind turbine competes well with the conventional type. Its economical advantage increases with increasing output power.

## WIND ENERGY CONVERSION SYSTEM WITH ELECTROMAGNETIC STABILISER. M. Kant, M. Berna.

Proceedings, vol 126, no 11, November 1979, p. 1201-1203.

The development of a novel medium-power (50kW) w.e.c.s. is outlined. This device, composed of a constant-pitch rigid motor and a double-stage generator, uses a particular electromagnetic braking to assure speed stabilisation.

## N60-19645 Midwest Research Inst., Golden, Colo. GENERAL RELIABILITY AND SAFETY METHODOLOGY AND ITS APPLICATION TO WIND ENERGY CONVERSION SYSTEMS

M. Edesess and R. D. McConnell Sep. 1979 52 p refs (Contract EG-77-C-01-4042) (SERI/TR-35-234) Avail. NTIS HC A04/MF A01

In conventional system reliability calculations, each component may be in the operable state or the under repair state. These calculations derive system unavailability, or the probability of the system's being down for repairs. By introducing a third component state between 'operable' and 'under repair'—namely, 'defective, but defect undetected'—the methods developed in this report enable system safety projections to be made in addition to availability projections. Also provided is a mechanism for computing the effect of inspection schedules on both safety and availability. A reliability and safety program (RASP) is detailed which performs these computations and also calculates costs for system inspections and repairs. RASP is applied to a simplified wind energy conversion system example. DOE

NO ILL WINDS FOR NEW MEXICO UTILITY, by Thomas W. Reddoch and John W. Klein, IEEE Spectrum, vol. 16, no. 3, March 1979, p.57-62.

It has been a little more than a year since the first Federally sponsored large wind generator joined the electric utility system in the town of Clayton, N.M., and while much remains to be studied, already it is clear: the results are encouraging. Linked to the town's present system of seven diesel generators, the revolving wind blades can supply 200 kW of output power, nearly 15 percent of Clayton's total power load during off-peak periods.

## OFF-SHORE BASED WIND TURBINE SYSTEMS (OB-WTS) FOR SWEDEN - A SYSTEMS CONCEPT STUDY

R. Hardell and O. Ljungstrom

Wind Engineering, vol. 3, no. 1, 1979, pp. 23-51.

*The Swedish wind energy prospecting program, initially concentrating on land based systems, now also includes studies of potential off-shore sitings, where higher specific energy output per available group station area is obtained. The cost of wind energy is very sensitive to median wind velocity at selected sites. Land areas with high winds and corresponding low cost wind energy are scarce in Sweden. Off-shore (OS) sites may prove to be more cost-effective and will reduce the land requirement for a given national wind energy production, or may even be needed for sufficient penetration of wind-electric energy into Sweden's network of the future.*

*Off-shore siting surveys along Sweden's coasts, utilizing depths less than 30 m, show availability of 5000 km<sup>2</sup> areas, with likely potential for 3300 km<sup>2</sup> in good wind areas suitable for WTS-installation. In typical cases, when moving a WTS site from a near shore, or good coastal, land area to off shore location, 10-20 km, the median wind increases from 8.5-9.5 m/s (H = 100 m) and the specific energy output (per turbine disc area) increases by 40%.*

*Design and installation of OS-WTS gives the freedom of using much larger unit sizes than on land, assembled complete and towed to sites, with options of relocation. This should enhance energy economy, system flexibility, and output per available group station area. Examples of design concepts, of 7-14 MW unit capacity, both HA- and VA- (Horizontal viz. Vertical Axis Turbines) are given, with associated cost estimates, and with outlooks to much bigger second generation designs of 20-30 MW units.*

*Current full scale prototype development in Sweden includes the option of OS-HA-concepts up to 4 MW size. Design criteria for such, requiring addition of load cases due to the wave and sea ice environment, etc, not found in land based units are discussed. OS means added costs of installation, etc, to be compensated by the higher energy production. At this early stage of study, a break-even case in this respect between land and sea based systems can be visualised.*

A79-19539 # Wind turbine generator wakes. P. M. Sforza, W. Stasi, M. Smorto, and P. Sheerin (New York, Polytechnic Institute, Farmingdale, N.Y.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, Paper 79-0113.* 10 p. 40 refs.

An experimental and theoretical investigation of the wake behind wind turbine generators is presented. The general features of such flows are reviewed and the applicability of past work on more conventional aerodynamic wakes is discussed. Modeling of the wind turbine and the atmospheric boundary layer in an environmental tunnel is described. Experimental results for such models are given. Theoretical modeling of the three-dimensional mixing process in the wake-boundary layer interaction region is performed and numerical solutions for such flows are discussed and compared to the experiments. (Author)

A79-19540 # Energy effectiveness of arbitrary arrays of wind turbines. P. B. S. Lissaman (Aero Vironment, Inc., Pasadena, Calif.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, Paper 79-0114.* 8 p. 9 refs.

A computer model for an arbitrary array of wind turbines is presented, in which the power available to each wind turbine in the array is determined for that wind turbine as 'receptor', with each of the other wind turbines acting as a wake generator. The power of the entire array is determined by summing over all the receptors and then determining the average. The discussion covers wake profiles, wake growth and turbulent entrainment (wake development in a nonturbulent and a turbulent infinite medium), effect of ground plane and neighboring wakes, and computer model. The basic equations employ basic fluid mechanical expressions related to drag conservation, wake growth due to turbulent entrainment, and a family of self-similar wake profiles obtained from experiment. This gives full definition of the wake velocity field and helps determine the velocity deficit for a given radius. Power output of selected arrays for all wind conditions is determined. Some typical results for various cases of interest are presented. S.D.

## THE ESTIMATION OF THE PARAMETERS OF THE WEIBULL WIND SPEED DISTRIBUTION FOR WIND ENERGY UTILIZATION PURPOSES. M. J. M. Stevens and P. T. Smulders.

Wind Engineering, vol 3, no 2, 1979, p. 132-146.

*This paper deals with methods for estimating the parameters of the Weibull wind speed distribution from a given set of wind speed data. Of the five methods presented, two are selected for wind energy evaluation studies: one uses Weibull probability paper, the other so-called percentiles. For a comparison both methods have been applied to the data from six meteorological stations. The simple graphical method using Weibull probability paper is preferred to that employing percentile estimators.*

## LIMITS TO WIND-POWER R. W. B. Best

Energy Conversion, vol.19, no. 2, 1979, pp. 71-72.

**Abstract**—Simple formulas are given for the change in wind-power, frictional stress and vertical energy transport in the atmospheric boundary layer, caused by the erection of windmill arrays. The limit to wind-power conversion appears to be around 1 W/m<sup>2</sup> of terrain in both coastal and inland areas.



N80-10594\*# National Aeronautics and Space Administration  
Lewis Research Center, Cleveland, Ohio

**SOME TECHNIQUES FOR REDUCING THE TOWER  
SHADOW OF THE DOE/NASA MOD-0 WIND TURBINE  
TOWER. Final Report**

Richard R. Burley, Joseph M. Savino, Lee H. Wagner, and James  
H. Diedrich. Sep. 1979. 129 p. refs.

(Contract DE-AB29-76-ET20370)

(NASA-TM 79202. DOE/NASA/20370-79/17. E-087) Avail.  
NTIS HC A07/MF A01 CSCL 10B

Wind speed profile measurements to measure the effect of  
a wind turbine tower on the wind velocity are presented.  
Measurements were made in the wake of scale models of the  
tower and in the wake of certain full scale components to  
determine the magnitude of the speed reduction (tower shadow).  
Shadow abatement techniques tested on the towers included  
the removal of diagonals, replacement of diagonals and horizontals  
with round cross section members, installation of elliptical shapes  
on horizontal members, installation of airfoils on vertical members,  
and application of surface roughness to vertical members.

A. W. H.

A79-41235

Composite rotor blades for large wind energy  
installations (Composite Rotorblatt für Grosse Windenergieanlage  
Growian). A. Kussmann, J.-P. Molloy, and D. Muser (Deutsche  
Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Institut  
für Bauweisen- und Konstruktionsforschung, Stuttgart, West Ger-  
many). *DFVLR-Nachrichten*, June 1979, p. 40-44. In German.

The design of large wind power systems in Germany is reviewed  
with attention given to elaboration of the total wind energy system,  
aerodynamic design of the rotor blade, and wind loading effects.  
Particular consideration is given to the development of composite  
glass fiber/plastic or carbon fiber/plastic rotor blades for such  
installations.

B. J.

**AEROELASTIC STABILITY AND RESPONSE OF HORIZONTAL  
AXIS WIND TURBINE BLADES**

S. B. R. Kottapalli, P. P. Friedmann and A. Rosen

*AIAA-Journal*, vol. 17, no. 12, Dec. 1979, pp.  
1381-1389.

Coupled flap-lag-torsion equations of motion of an isolated horizontal axis wind turbine (HAWT) blade have  
been formulated. The analysis neglects blade-tower coupling. The final nonlinear equations have periodic  
coefficients. A new and convenient method of generating an appropriate time-dependent equilibrium position,  
required for the stability analysis, has been implemented and found to be computationally efficient. Steady-state  
response and stability boundaries for an existing (typical) HAWT blade are presented. Such stability boundaries  
have never been published in the literature. The results show that the isolated blade under study is basically  
stable. The tower shadow (wake) has a considerable effect on the out-of-plane response but leaves blade stability  
unchanged. Nonlinear terms can significantly affect linearized stability boundaries; however, they have a  
negligible effect on response, thus implying that a time-dependent equilibrium position (or steady-state  
response), based completely on the linear system, is appropriate for the type of HAWT blades under study.

**14290 OFFSHORE WIND POWER POTENTIAL**

**KEY WORDS:** Energy; Models; Planning; Statistical analysis; Wind  
(meteorology)

**ABSTRACT:** The offshore region has been cited as a location to construct wind energy  
conversion systems because this region offers reduced surface drag; therefore, higher wind  
speeds and greater wind power may be harnessed than on land. A result of a statistical  
analysis of wind speed records for the Gulf of Maine region shows that six seasonal wind  
groups can be identified and that the gamma distribution adequately describes the wind  
speed frequency. The results show that for six months of the year, higher wind speeds can  
be obtained offshore than inland. The use of the gamma distribution of wind speed for the  
operational characteristics of wind turbines show there is questionable gain in operating a  
turbine in an offshore environment. Historical wind speed records of the Boston Logan  
Airport, the Boston Lightship, and data collected on board ships that traversed the Gulf of  
Maine region were used in the study.

**REFERENCE:** Ossenbruggen, Paul J., Prgent, Gerard P., and Meeker, L. David.  
"Offshore Wind Power Potential," *Journal of the Energy Division, ASCE*, Vol. 105, No.  
EY1, Proc. Paper 14290, January, 1979, pp. 81-92.

**A79-19541 # The Madaras Rotor Power Plant - An alternate  
method for extracting large amounts of power from the wind.** D. H.  
Whitford and J. E. Minardi (Dayton, University, Dayton, Ohio).  
*American Institute of Aeronautics and Astronautics, Aerospace  
Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, Paper  
79-0115*, 12 p. Contract No. EY-76-S-01-2554.

The Madaras Rotor Power Plant concept is discussed, and  
studies involving wind tunnel tests, electromechanical analysis,  
performance analysis, and cost analysis are reported. The Madaras  
concept uses rotating cylinders, vertically mounted on flat cars, to  
react with the wind like a sail and propel an endless train of  
connected cars around a closed track at constant speed. Electricity is  
generated at each car by alternators geared to the wheels. The  
analysis indicates that racetrack-shape plan-forms but not circular  
plan-forms of tracks might be economically attractive. Racetrack  
plants with capacities as high as 228 MW and annual energy outputs  
of 975,000,000 kWh/yr are considered. Energy costs of MOD-1  
horizontal axis wind turbines and of Madaras plants are compared.

N. L.

**A79-43681 # Performance of windmills in a closely spaced  
array.** B. M. Pershing (Aerospace Corp., El Segundo, Calif.). *Journal  
of Energy*, vol. 3, May-June 1979, p. 185-187, 7 refs.

A model based on momentum theory is developed for windmill  
performance with slipstream interference. Only the two-rotor inter-  
ference problem is considered. The windmill performance is obtained  
from momentum theory with the approach velocity of the blanketed  
part of the rotor assumed to correspond to the fully developed wake  
velocity of the upstream windmill. It is shown that wake interference

between windmills in a closely spaced array strongly degrades system  
performance, the power output varying cosine-like from interference-  
free to fully blanketed operation. Performance improvement results  
from a more favorable distribution of the kinetic energy of the  
impinging air over each rotor of the array.

S. D.

A79 37901 Offshore wind energy systems for the U.K. P. J. Musgrove (Reading, University, Reading, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79 37842 15-44) London, Institution of Electrical Engineers, 1979, p. 309-312. 16 refs.

Some of the more important factors affecting the design of offshore wind energy systems are discussed. It is shown that power densities in offshore winds are attractively high, of the order of 300 kW/linear meter (perpendicular to the wind direction). The economics of offshore operation strongly favors the use of large wind turbines (about 100 m diameter) and a low rated wind speed is also advantageous. A typical offshore wind energy system might comprise a 10 x 10 array of 100 m diameter wind turbines to give a cluster rating of 600 MW and a plant factor of about 40%. B.J.

N78-26504\*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

#### LARGE HORIZONTAL AXIS WIND TURBINE DEVELOPMENT

William H. Robbins and Ronald L. Thomas. 1979. 16 p. refs. Presented at the Wind Energy Innovative Systems Conf., Colo. Springs, Colo., 23-25 May 1979, sponsored by Solar Energy Res. Inst.

(Contract E(49-26)-1059)

(NASA-TM-79174, DOE/NASA/1059-79/2, E-039) Avail. NTIS HC A02/MF A01 CSCL 10A

An overview of the NASA activities concerning ongoing wind systems oriented toward utility application is presented. First-generation technology large wind turbines were designed and are in operation at selected utility sites. In order to make a significant energy impact, costs of 2 to 3 cents per kilowatt hour must be achieved. The federal program continues to fund the development by industry of wind turbines which can meet the cost goals of 2 to 3 cents per kilowatt hour. Lower costs are achieved through the incorporation of new technology and innovative system design to reduce weight and increase energy capture. M.M.

#### STUDIES OF THE AERODYNAMIC PERFORMANCE OF A 10 kW HORIZONTAL-AXIS WINDMILL, by R.L. Figard and J.A. Schetz.

Journal of Energy, vol. 3, no. 1, Jan./Feb. 1979, p. 3-7.

The aerodynamic performance of a modern, high-tip-speed, three-bladed windmill rated at 10 kW at 30 mph was studied by three methods. First, the results of field tests of the actual device with both a resistive and a battery-charging electric load are reported. Second, the predictions of a simple blade-element analysis are presented and compared with the field data. Aerodynamic blade section coefficients of an actual blade section were measured in a wind tunnel and used as input in the analysis. Third, wind tunnel test results for a 1/5th scale model are given. Reynolds number simulation from model to prototype is considered in detail. The results of all three efforts are compared, and good agreement is shown.

#### EXPERIMENTAL DEMONSTRATION OF THE DIFFUSER-AUGMENTED WIND TURBINE CONCEPT. B. L. Gilbert and K. M. Foreman.

Journal of Energy, vol. 3, no. 4, July-August 1979, p. 235-240.

The surface area requirements of an efficient diffuser has been reduced by innovative use of the external wind to produce a cost-effective wind energy conversion system (WECS). Three sets of tests were conducted on very compact diffusers: 1) on small-scale models using screens to simulate a real turbine; 2) on ten times larger scale models with screens; and 3) on a real turbine. The first-generation nonoptimized diffuser-augmented wind turbine (DAWT) configuration is a conical, 60 deg included angle diffuser with an area ratio of 2.78 controlled by two tangential injection slots for boundary-layer control. This baseline model provided over three times the power of a conventional WECS with the same turbine efficiency, diameter, and free wind. An optimized configuration should provide augmentations greater than four.

N80 18565\*# General Electric Co., Philadelphia, Pa. Space Div.

#### APPENDIX: MOD-1 WIND TURBINE GENERATOR ANALYSIS AND DESIGN REPORT, VOLUME 2 Final Report.

May 1978. 425 p.

(Contract NAS37-058; EX-77-A-29-1010)

NASA CR-159496, DOW/NASA/0058-79/2-Vol-2-App) Avail.

NTIS HC A18/MF A01 CSCL 10B

The MOD-1 detail design is appended. The supporting analyses presented include a parametric system trade study, a verification of the computer codes used for rotor loads analysis, a metal blade study, and a definition of the design loads at each principal wind turbine generator interface for critical loading conditions. Shipping and assembly requirements, composite blade development, and electrical stability are also discussed. K.L.

A80-23537

An oscillatory wind energy converter. G. Ahmadi (Shiraz University, Shiraz, Iran). Wind Engineering, vol. 3, no. 3, 1979, p. 207-215. 18 refs. Research supported by Shiraz University.

The paper reviews the concept of wind energy conversion through the oscillation of an aerodynamically unstable system and a small wind energy converter model of H section is presented. The unit is mounted on a shaft connected to a mechanical rectifier and the restoring couple is supplied by a steel rod pendulum. The model was tested at the exit of a wind tunnel, and a nonlinear theory predicting the power coefficient for such a model was developed. The test results are compared to the theoretical predictions showing a good correlation between theoretical and experimental values. It is also shown that the efficiency of energy conversion decreases with increasing wind speed. It is concluded that although the oscillating converter has the advantage of simple design and low construction cost, which may make it attractive for use in remote areas of developing countries, the low value of its power coefficient is considered a deficiency. L.M.

MEHRKAM'S WINDMILLS-HE'S OVERPOWERING NASA, by Paul Gipe.  
Popular Science, vol. 214, no. 4, April 1979, p.82-83.

Off-the-shelf parts and  
simple assembly produce  
250 kilowatts at low cost

**N79 30719\*** National Aeronautics and Space Administration.  
Lewis Research Center, Cleveland, Ohio.  
**WIND TURBINES FOR ELECTRIC UTILITIES: DEVELOP-  
MENT STATUS AND ECONOMICS**

J. R. Ramler and R. M. Donovan 1979 21 p refs Presented  
at Terrest Energy Systems Conf., Orlando, Fla., 4-6 Jun. 1979,  
sponsored by AIAA

(Contract E(49-26)-1028)

(NASA TM-79170; E-035; DOE/NASA/1028-79/23) Avail.  
NTIS HC A02/MF A01 CSCL 10B

The technology and economics of the large, horizontal-axis  
wind turbines currently in the Federal Wind Energy Program are  
presented. Wind turbine technology advancements made in the  
last several years are discussed. It is shown that, based on  
current projections of the costs of these machines when produced  
in quantity, they should be attractive for utility application. The  
cost of electricity (COE) produced at the busbar is shown to be  
a strong function of the mean wind speed at the installation  
site. The breakeven COE as a fuel saver is discussed and the  
COE range that would be generally attractive to utilities is  
indicated.

Author

**N79 30772\*** Sandia Labs., Albuquerque, N. Mex.  
**SOME VARIABILITY STATISTICS OF AVAILABLE WIND  
POWER**

J. W. Reed Mar 1979 50 p refs

(Contract EY-76-C-04-0789)

(SAND-78-1735) Avail. NTIS HC A03/MF A01

The long term variability of available wind power was studied  
in ten year records of hourly wind speed observations at fifteen  
selected weather stations. Month by month and year by year  
sums of wind power occurrences were used to generate average,  
standard deviation, and autocorrelation statistics. The amplitude  
of the annual cycle in available wind power was at least 70%  
of the average at all locations. Long term integrated power  
production showed maxima and minima that differed by 36 to  
91% from average annual production.

DOE

WIND POWER T. ROUGH KITES, J.S. Goela

Mechanical Engr., v.101, no.6, June 1979, p.42

ADVANCED DESIGN PUTS NEW TWIST IN WINDMILL  
GENERATOR. E. F. Lindsley.

Popular Science, vol 215, no 4, October 1979.  
p. 84-85.

Hollow blades, superstrong magnets, unique controls-for  
your home?

**N79 28725\*** National Aeronautics and Space Administration  
Lewis Research Center, Cleveland, Ohio

**SAFETY CONSIDERATIONS IN THE DESIGN AND OPERA-  
TION OF LARGE WIND TURBINES Final Report**

Dwight H. Reilly Jun 1979 38 p refs Sponsored in part by  
DOE

(Contract DE-AI01-79ET20305)

(NASA TM-79193; E-067; DOE/NASA/20305-79/3) Avail.  
NTIS HC A03/MF A01 CSCL 10B

The engineering and safety techniques used to assure the  
reliable and safe operation of large wind turbine generators utilizing  
the Mod 2 Wind Turbine System Program as an example is  
described. The techniques involve a careful definition of the wind  
turbine's natural and operating environments, use of proven  
structural design criteria and analysis techniques, an evaluation  
of potential failure modes and hazards, and use of a fail safe  
and redundant component engineering philosophy. The role of  
an effective quality assurance program, tailored to specific  
hardware criticality, and the checkout and validation program  
developed to assure system integrity are described.

Author

**N80-14543\*** Department of Energy, Washington, D. C.  
**COMMERCIALIZATION STRATEGY REPORT FOR SMALL  
WIND SYSTEMS**

Louis V. Divone, R. Blaustein, J. Gros, A. K. Ingberman, W. L.  
R. Rice, and S. J. Taylor [1979] 46 p refs

(TID-28844-Draft) Avail. NTIS HC A03/MF A01

The commercial readiness of small wind systems is addressed.  
Barriers to be overcome before this technology is ready to be  
used commercially are cited and possible actions that might be  
considered to remove specific barriers are identified. The full  
implications of the various proposed actions have not been fully  
developed and many actions listed undoubtedly have substantial  
problems associated with them.

DOE

**SUMMARY OF ATMOSPHERIC WIND DESIGN CRITERIA  
FOR WIND ENERGY CONVERSION SYSTEM DEVELOPMENT.**

Walter Frost, Tenn. Univ. Space Inst. and

Robert K. Turner, NYSC. Jan. 1979. 54p.



**N79-31779\*** National Aeronautics and Space Administration, Washington, D. C.

**INVESTIGATION OF A GENERATOR SYSTEM FOR GENERATING ELECTRICAL POWER, TO SUPPLY DIRECTLY TO THE PUBLIC NETWORK, USING A WINDMILL**

C. Tromp. Aug. 1979. 159 p. refs. Transl. into ENGLISH of "Onderzoek aan een Generatorsysteem voor het Opwekken van, Direkt aan het Openbare Net te Leveren, Elektrische Energie Net Behulp van een Windmolen". Delft Univ. of Technol., Power Electron. Lab., Netherlands, May 1957. 122 p. Transl. by Kanner (Leo) Associates, Redwood City, Calif. (Contract NASw-3199)

(NASA-TM-75497) Avail: NTIS HC A08/MF A01 CSCL 10B

A windpowered generator system is described which uses a windmill to convert mechanical energy to electrical energy for a three phase (network) voltage of constant amplitude and frequency. The generator system controls the windmill by the number of revolutions so that the power drawn from the wind for a given wind velocity is maximum. A generator revolution which is proportional to wind velocity is achieved. The stator of the generator is linked directly to the network and a feed converter at the rotor takes care of constant voltage and frequency at the stator.

A.W.H.

**A79-37891**

Windpower generation on a large scale. T. Mensforth. In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 268-272. 5 refs.

Some considerations on windpower generation are presented with reference to a 10 MW windmill. A general description of the windmill is given and attention is paid to rotor design. The influence of wind-height profiles is then discussed, taking into account wind thrust, economy due to size, optimal ground clearance, and accuracy of performance estimates.

B.J.

**N80-11558\*** General Electric Co., Philadelphia, Pa. Space Div.

**EXECUTIVE SUMMARY: MOD-1 WIND TURBINE GENERATOR ANALYSIS AND DESIGN REPORT Final Report**

Mar. 1979. 61 p.

(Contracts NAS3-20058; EC-77-A-29-1010)

(NASA-CR-159497; DOE/NASA/0058-79/3) Avail: NTIS HC A04/MF A01 CSCL 10A

Activities leading to the detail design of a wind turbine generator having a nominal rating of 1.8 megawatts are reported. Topics covered include (1) system description; (2) structural dynamics; (3) stability analysis; (4) mechanical subassemblies design; (5) power generation subsystem; and (6) control and instrumentation subsystem.

A.R.H.

**N80-18558\*** National Aeronautics and Space Administration, Washington, D. C.

**CONTROL STRATEGY FOR A VARIABLE-SPEED WIND ENERGY CONVERSION SYSTEM**

A. Jacob, D. Veillette, and V. Rajagopalan. Nov. 1979. 10 p. refs. Transl. into ENGLISH from Proc. of New York Inst. of Elec. Engineers Inc., 1978 p. 528-531. In FRENCH Presented at Can. Commun. and Power Conf., Montreal, 18-20 Oct. 1978. Transl. by Kanner (Leo) Associates, Redwood City, Calif. (Contract NASw-3199)

(NASA-TM-75512) Avail: NTIS HC A02/MF A01 CSCL 10A

A control concept for a variable-speed wind energy conversion system is proposed, for which a self-excited asynchronous cage generator is used along with a system of thyristor converters. The control loops are the following: (1) regulation of the entrainment speed as function of available mechanical energy by acting on the resistance couple of the asynchronous generator; (2) control of electric power delivered to the asynchronous machine, functioning as a motor, for start-up of the vertical axis wind converter; and (3) limitation of the slip value, and by consequence, of the induction currents in the presence of sudden variations of input parameters.

Author

**N80-14844\*** Department of Energy, Washington, D. C.  
**COMMERCIALIZATION STRATEGY REPORT FOR LARGE WIND SYSTEMS**

Louis V. Divone, R. Blaustein, J. Gros, A. K. Ingberman, W. L. R. Rice, and S. J. Taylor [1979] 41 p.

(TID-28843-Draft) Avail: NTIS HC A03/MF A01

The commercialization of wind turbines is analyzed concerning technical readiness; market and economic aspects; environmental impacts; institutional acceptance; benefit analysis; and commercialization development strategy.

DOE

**WIND BLOWS ANEW. L. A. Kilar**

**POWER**, vol 123, no 5 May 1979, p. 40-42.

**Harnessing tomorrow's energy sources gets increasingly urgent** as reserves of conventional fuels dwindle. Article examines potential and problems attending solar and wind energy and fuel cells, suggests the promise of solar energy appears best for both utility and industrial plants

**N80-14487\*** Purdue Univ., Lafayette, Ind.  
**ANALYSIS AND SIMULATION OF WIND ENERGY SYSTEMS**

**Final Report**

P. C. Krause. Nov. 1979. 60 p. refs. (Grant NSG-3237)

(NASA-CR-162538) Avail: NTIS HC A04/MF A01 CSCL 10A

Using a wind fluctuation model, simulation results of the mechanical and electrical systems were obtained for the MOD-2 wind turbine generator system. The dynamic performance of the MOD-2 was studied during wind gusts of the 1-cos form from a constant wind velocity. If these are the type of wind fluctuations to which the wind systems will be subjected to, then the design of the MOD-2 appears adequate. There was one exception to this; with a rate limit incorporated in the pitch controller, an instability occurred during a 'down' gust which caused continuous, unbounded switching between the high and low modes. This is a control design problem which appears to be correctable.

R.E.S.

**N80-16453\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**LARGE WIND TURBINE DESIGN CHARACTERISTICS AND R AND D REQUIREMENTS**

Seymour Lieblein, ed. (Technical Report Services, Rocky River, Ohio) Dec. 1979. 459 p. refs. Conf. held at Cleveland, 24-26 Apr. 1979; sponsored in part by DOE

(NASA-CP-2106; CONF-7904111) Avail: NTIS HC A20/MF A01 CSCL 10B

Detailed technical presentations on large wind turbine research and development activities sponsored by public and private organizations are presented. Both horizontal and vertical axis machines are considered with emphasis on their structural design. For individual titles, see N80-16454 through N80-16482.

**A79-31426**

NRC's wind energy program. R. S. Rangi, P. South, and R. J. Templin (National Research Council, Ottawa, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 15 p.

This paper describes current work on wind power assessment and on the Vertical Axis Wind Turbines at the National Research Council (NRC) Ottawa. A map showing the annual average wind power density is presented. The electrical wind power potential for all of Canada and individual provinces has been calculated from the wind power density. The wind power potential is also assessed for: (a) all land area, (b) existing electrical network +300 km, (c) existing electrical network +150 km. The theoretical and development work on the VAWT and also the demonstration projects that are sponsored by National Research Council are described. In particular, the preliminary performance data from the 200 kW Magdalen Island unit is included.

(Author)

DANISH AMATEURS BUILD THE WORLD'S BIGGEST WINDMILL,  
by John Dornberg.  
Popular Science, vol. 214, no. 1, January 1979,  
p. 80-85.

**Learning by doing: Schools  
set a 2000-kilowatt example  
for wind-rich Denmark**

Test Site Picked for Cluster of Largest Wind Turbines

Machine Design, Vol. 51, No. 27, 22 November 1979,  
p. 6

**SIMPLICITY MEANS ECONOMY FOR WINDMILL DESIGN**

Machine Design, vol 51, no 28, December 6, 1979,  
p. 134.-/35

**THE AERODYNAMIC EFFICIENCY OF WINDMILLS.**

G. M. Lilley

The Aeronautical Quarterly, Vol. 29, Pt. 1,  
February 1978, p. 1-17.

**Summary:** The paper reproduces the results of an earlier report on the vortex theory of windmills and follows that theory through to establish the aerodynamic design procedure for a horizontal axis windmill. The results are shown to differ considerably from those given in a recent paper by Griffith and the differences are explained. The main conclusion is that, when full allowance is made for the drag of the blades, hub and tip losses, and losses due to interference with the support tower, the power output coefficient or efficiency of a horizontal axis windmill cannot exceed 30 to 35 per cent, as compared to an ideal efficiency of 59 per cent.

**NASA CP-2034 Windmills - NASA Mod-1 1978**

**WIND TURBINE STRUCTURAL DYNAMICS.** Dean R. Miller, LeRC, ed. (Workshop sponsored by DOE and held LeRC, Nov. 15-17, 1977). Mar. 1978. 280p.

(CONF-771148—, pp 15-29) MOD-1 WTG dynamic analysis. Stahle, C.V. Jr. (General Electric Co., Valley Forge, PA). 1978.

From Wind turbine structural dynamics conference; Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

The dynamic analysis is presented of the MOD-1 2000 kW horizontal-axis wind turbine. After briefly describing the MOD-1 design, the dynamic analysis used to evaluate the dynamic loads and structural interactions is discussed. The resonant frequency placement, the treatment of unsteady wind loading and the dynamic load sensitivity to frequency shifts are reviewed for the design.

A79-10238

Experimental demonstration of the Diffuser Augmented Wind Turbine concept. B. L. Gilbert and K. M. Foreman (Grumman Aerospace Corp., Research Dept., Bethpage, N.Y.). In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings, Volume 3. (A79-10001 01-44) Warrendale, Pa., Society of Automotive Engineers Inc., 1978, p. 2082-2089. 6 refs. Contract No. EY-76-C-2-2616.

The Diffuser Augmented Wind Turbine (DAWT) is one of the advanced concepts being investigated to improve the economics of wind energy conversion systems (WECS). Very compact diffusers using boundary layer control have been examined experimentally. Small scale model testing with screens and centerbodies to simulate a real turbine was used to choose a baseline diffuser configuration. This design is a conical, 60-deg included angle diffuser with an area ratio of 2.78 controlled by two tangential injection slots. The configuration also has been tested at ten times greater physical size and up to 3.5 times greater wind speed using screens and a real turbine. This first generation, nonoptimized DAWT configuration should provide about four times the power of a conventional WBCS with the same turbine efficiency, diameter, and wind at optimum turbine disk loading.

(Author)

**NASA TP-1359 Windmills - Resources 1978**

**ENGINEERING HANDBOOK ON THE ATMOSPHERIC ENVIRONMENTAL GUIDELINES FOR USE IN WIND TURBINE GENERATOR DEVELOPMENT.** Walter Frost, B.H. Long, Tenn. Univ. Space Inst. and R.E. Turner, MSFC. Dec. 1978. 372p.

(CONF-771148—) Wind turbine structural dynamics. (National Aeronautics and Space Administration, Cleveland, Ohio (USA). Lewis Research Center). 1978. 290p. Dep. NTIS, PC A13/MF A01.

From Wind turbine structural dynamics conference, Cleveland, OH, USA (15 Nov 1977).

Separate abstracts are included for each of the 26 papers presented concerning the design and performance of wind turbines.

(SAND-77-1375) Performance evaluation of wind energy conversion systems using the method of bins: current status. Akins, R.E. (Sandia Labs., Albuquerque, N.Mex. (USA)). Mar 1978. Contract EY-76-C-04-0789. 21p. Dep. NTIS, PC A02/MF A01.

A detailed description of the method of bins, a technique of data collection and reduction for field performance evaluation of Wind Energy Conversion Systems (WECS) is provided. The method of bins is a straightforward yet useful approach to the complex problem of relating the response of a WECS to a variable wind field. Examples of typical results obtained using the method of bins are presented. Methods of determining that the measure of performance of a WECS obtained is correct are outlined. Areas in which further modifications to the technique may be appropriate are also discussed.

LORC, (CONF-771148—, pp 1-13) Comparison of computer codes for calculating dynamic loads in wind turbines. Spera, D.A. (Lewis Research Center, Cleveland). 1978.

From Wind turbine structural dynamics conference, Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

The development of at least seven codes by NASA and its contractors is described. As might be expected in an area of new technology, these codes differ considerably in approach and technique. Because of the generally complicated nature of any structural dynamics analysis, a detailed comparison of seven computer codes is extremely difficult. Therefore, the objectives of this study have been limited to the following: to present a brief overview of each code and identify sources for further detailed information, and to compare the performance of each code against two sets of test data measured on the 100 kW Mod-0 wind turbine, an experimental machine in operation at NASA's Plum Brook Station near Sandusky, Ohio. Comparison on the basis of cyclic loads, peak loads, and harmonic contents was selected.

(CONF-771148—, pp 31-37) Simplified modeling for wind turbine modal analysis using nastran. Sullivan, T.L. (Lewis Research Center, Cleveland). 1978.

From Wind turbine structural dynamics conference, Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

A simplified finite element model of the Mod-0 wind turbine tower is described. Use of this model greatly reduces the computer time required for modal analysis. The model provides good accuracy in predicting tower frequencies and mode shapes as long as the tower bending mode shape resembles the first bending mode shape of a cantilever beam. Several applications where the simplified model was used for modal analysis are described.

(CONF-771148—, pp 53-60) Aeroelastic analysis of wind energy conversion systems. Dugundji, J. (Massachusetts Inst. of Tech., Cambridge). 1978.

From Wind turbine structural dynamics conference, Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

An aeroelastic investigation of horizontal axis wind turbines is described. The study is divided into two simpler areas, namely, the aeroelastic stability of a single blade on a rigid tower, and the mechanical vibrations of the rotor system on a flexible tower. Some resulting instabilities and forced vibration behavior are described.

(CONF-771148—, pp 71-76) Flow field analysis. Cliff, W.C.; Verholek, M.G. (Battelle Pacific Northwest Labs., Richland, WA). 1978.

From Wind turbine structural dynamics conference, Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

The average mean wind speed integrated over a disk is shown to be extremely close to the mean value of wind speed which would be measured at the center of a disk for most geometries in which a WECS (Wind Energy Conversion System) would operate. Field test results are presented which compare instantaneous records of wind speed integrated over a disk with the wind speed measured at the center of the disk. The wind field that a rotating element would experience is presented which has been synthesized from the outputs of an array of anemometers.

(CONF-771148—, pp 95-101) Analytical testing techniques. Jones, R. (Kaman Aerospace Corp., Bloomfield, CT). 1978.

From Wind turbine structural dynamics conference, Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

Structural Dynamic Analytical Testing Techniques can be a tool to determine the source of structural dynamic problems and the solution to these problems. Analytical testing techniques are based upon new and unique dynamic testing methods and analysis of test results. Thus, these methods apply primarily to constructed wind turbine systems. This paper gives a summary of these methods.

(CONF-771148—, pp 103-108) Influence of wind turbine foundation. Yee, S.T. (Lewis Research Center, Cleveland). 1978.

From Wind turbine structural dynamics conference, Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

The 200 kW Mod-0A wind turbine was modeled using a 3 lumped mass-spring system for the superstructure and a rotational spring for the foundation and supporting soil. Natural frequencies were calculated using soil elastic moduli varying from 3000 to 22,400 psi. The reduction in natural frequencies from the rigid foundation case ranged up to 20 percent.

(CONF-771148—, pp 157-166) Drive train dynamic analysis. Giansante, N. (Kaman Aerospace Corp., Bloomfield, CT). 1978.

From Wind turbine structural dynamics conference, Cleveland, OH, USA (15 Nov 1977).

METHODS FOR ATTENUATING WIND TURBINE AC GENERATOR OUTPUT VARIATIONS. H. Gold. p.179-186.



**DYNAMICS OF DRIVE SYSTEMS FOR WIND ENERGY CONVERSION.**  
M. Martinez-Sanchez. p.187-194.

(CONF-771148—, pp 195-218) Some alternative dynamic design configurations for large horizontal axis WECS. Hohenemser, K.H. (Washington Univ., St. Louis). 1978.

From Wind turbine structural dynamics conference, Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

The present U.S. development effort toward large horizontal axis WECS concentrates on the configuration with two rigid blades with collective pitch variation and a yaw gear drive. Alternative configurations without yaw gear drive are considered where the rotor is either self-centering or where the yaw angle is controlled by blade cyclic pitch inputs. A preliminary evaluation of the dynamic characteristics for these alternative design configurations is presented.

(CONF-771148—, pp 243-254) Fixed pitch wind turbines. Fenn, D.B.; Viterna, L.A. (Lewis Research Center, Cleveland). 1978.

From Wind turbine structural dynamics conference, Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

Wind turbines designed for fixed pitch operation offer potential reductions in the cost of the machine by eliminating many costly components. Studies have shown that a rotor can be designed which produces the same energy annually as Mod-G but which regulates its power automatically by progressively stalling the blades as wind speed increases. Effects of blade twist, taper, root cutout, and airfoil shape on performance are discussed. Unfortunately, fixed pitch rotors are not self-starting when the pitch is set to maximize energy production per year. Various starting techniques are discussed.

(CONF-771148—, pp 261-264) Plans for wind energy system simulation. Dreier, M.E. (Paragon Pacific, Inc., El Segundo, CA). 1978.

From Wind turbine structural dynamics conference, Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

Two new analysis tools, one a digital computer code and the other a special purpose hybrid computer, are introduced. The digital computer program, the Root Perturbation Method or RPM, is a new implementation of the classic Floquet procedure which circumvents numerical problems associated with the extraction of Floquet roots. The hybrid computer, the Wind Energy System Time-domain simulator (WEST), yields real-time loads and deformation information essential to design and system stability investigations.

(CONF-771148—, pp 275-283) Brush wind turbine generator as described in Scientific American of December 20, 1890. Spera, D.A. (Lewis Research Center, Cleveland). 1978.

From Wind turbine structural dynamics conference, Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

An historic wind turbine generator is described which operated in Cleveland, Ohio, from 1888 to 1908. The machine had a 144-blade rotor 56 feet in diameter, a pivoted tower 60 feet high, and a maximum output of 12 kW DC. The description is based on an 1890 article in Scientific American journal.

**WIND POWER POTENTIAL IN THE PACIFIC NORTHWEST**, by Robert W. Baker and E. Wendell Hewson.  
Journal of Applied Meteorology, vol. 17, no. 12, December 1978, p. 1814-1826.

Wind energy potential is examined in terms of the amount of time that power producing winds in the range 4.5-27.0 m s<sup>-1</sup> occur. The resulting "effective wind power density" is examined on a seasonal basis at the various sites throughout the five-state area. The analysis indicates that there are large wind power resources not only during storms but also with the clear skies associated with high pressure to the northeast. In summer the dominant high pressure system over the Pacific results in substantial wind power along the coast and through the Columbia Gorge and to the east.

A preliminary indication of the energy production which could have been produced by a 1175 unit, 2140 MW rated, seven-site network in the Pacific Northwest during the period July 1976-February 1977 is 3.8x10<sup>9</sup> KWh. To obtain the lowest cost per unit energy output the wind turbine rotor (WTG) unit should be sized according to the strength of the wind regime. However, a comparison of the cost per kilowatt-hour production for various size WTG ratings reveals that for a minor change in price, a sizable increase (or decrease) in energy output can be experienced.

**AN EXPERIMENTAL INVESTIGATION OF A CLASS OF RESISTANCE-TYPE, DIRECTION-INDEPENDENT WIND TURBINES.**

S. Sivasegaram.

Dept. of Mechanical Engineering, Faculty of Engineering, University of Sri Lanka, Peradeniya Campus, Sri Lanka.

Energy. 1978, February, 23-30.

The resistance-type, direction-independent wind turbine is suitable for the generation of power on a small scale in developing countries. So far, all work on this class of wind turbine seems to be restricted to the Savonius rotor. The present paper reports the findings of an experimental investigation of an entire class of wind turbines which includes the conventional Savonius rotor. The influence of four rotor-geometry parameters (i.e. number of blades, blade angle, blade location and angle of setting of the blade) is studied and discussed on the basis of two performance criteria (i.e. turbine efficiency and performance on the basis of blade area). The existence of optimum design parameters is established and the possibility of improving substantially on the performance of the Savonius rotor is demonstrated. Some possible applications of the present class of turbines are briefly commented on.

**THE 1979 WIND ACCESS CATALOG.**

Wind Power Digest, no. 14, Winter 1978, p.23.

THE BIG WINDMILL AT TVIND.  
Marshal F. Merriam

Sunworld, Vol. 2, No. 2, May 1978, p. 57-59.

The Tvind windmill is unusual in several respects. First, it is by far the largest windmill standing in the world today, and by a small margin is the largest ever built. It is a horizontal axis, 3-blade, downwind propeller, with the blades sweeping a circle 54 meters in diameter. The hub is more than 50 meters above the ground.

In addition to being of extraordinary size (with all the engineering which that implies), the machine includes a number of technical features that are imaginative and novel. The blades, for example, are constructed of fiberglass and plastic foam and weigh only 5 tons each.

A79-20825 \* Background and system description of the Mod 1 wind turbine generator. E. H. Ernst (General Electric Co., Valley Forge, Pa.). In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 403-408. Contract No. NAS3-20058.

The Mod-1 wind turbine considered is a large utility-class machine, operating in the high wind regime, which has the potential for generation of utility grade power at costs competitive with other alternative energy sources. A Mod-1 wind turbine generator (WTG) description is presented, taking into account the two variable-pitch steel blades of the rotor, the drive train, power generation/control, the nacelle structure, and the yaw drive. The major surface elements of the WTG are the ground enclosure, the back-up battery system, the step-up transformer, elements of the data system, cabling, area lighting, and tower foundation. The final system weight (rotor, nacelle, and tower) is expected to be about 650,000 pounds. The WTG will be capable of delivering 1800 kW to the utility grid in a wind-speed above 25 mph.

G.R.

#### VORTEX AFFECTED BY THE CONICAL SHAPE OF GENERATOR IN TORNADO TYPE WIND ENERGY SYSTEM.

Jwo-Min Chen.

Industrial Aerodynamics, v.3, 1978, p.307-313.

A mathematical analysis of a vortex which is generated by a stationary tower with a partially opening top and directed by vertical vanes is presented. With the conical-shape generator tower considered, a concentrated vortex and higher pressure drop can be obtained from this tornado-type wind-energy system.

NASA CP-2034 Windmill blades

1978

WIND TURBINE STRUCTURAL DYNAMICS. Dean R. Miller, LaRC, ed. (Workshop sponsored by DOE and held LaRC, Nov.15-17,1977). Mar.1978. 290p.

Department of Energy,  
Washington, D.C.  
Workshop on Wind Turbine  
Structural Dynamics

CONF-771143

Nov.15-17,  
1977

COMPOSITE BLADE FABRICATION. C.M. MINKE. P.255-56.

A78-49949 Research in the electrofluid dynamic (EFD) wind driven generator. J. E. Minardi and M. O. Lawson (Dayton, University, Dayton, Ohio). In: NAECON '78; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 16-18, 1978. Volume 2. (A78-49851 22-04) New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 869-873. 8 refs. Contract No. EY-76-S-02-4130.

The Electrofluid Dynamic (EFD) wind driven generator directly converts wind energy to electrical energy without moving parts. Conventional wind turbines are currently limited in size, with the greatest diameter presently envisaged being 300 to 400 feet. For the EFD wind driven generator there are no fundamental reasons to restrict the size; therefore, economics of scale and far larger powers than conventional systems can be realized. Analyses predict favorable performance characteristics for EFD wind generators; however, specific experimental data have been lacking. Research areas presently being emphasized are discussed and performance of experimental arrays being conducted in an Eiffel-type wind tunnel are also discussed.

(Author)

#### HYDRAULIC WINDMILLS

David Scott

Popular Science, vol. 212, no. 4 April 1978  
p. 6-10 and 192

Two British-designed wind  
turbines use hydraulics to  
produce heat and electricity

Proceedings of the National Conference of the American Wind Energy Association: Amarillo, Texas, 1-5 March 1978.

Available from the Alternative Energy Institute, West Texas State University, Canyon, Texas 79016. Price \$9.00.

The profound changes that have taken place in general attitudes to alternative energy systems in the US during the last five years or so are reflected in the balance of the 23 papers comprising these Proceedings; almost half of them are concerned with programmes sponsored by major authorities and deal with overall commercial, legislative and administrative problems of wind power development rather than with the technical aspects.

To comment first on the technical papers, it is interesting to speculate upon the extent to which the balance of the dozen presentations in this category may or may not represent the pattern of development in the US field. Horizontal axis machines still predominate in all sizes from the 200 kW Mod OA turbines - undeterred, it seems, by the problems at Plum Brook - to the small machines tested with such enthusiasm at Rocky Flats, where Andrew Trenka's paper lists 11 horizontal machines but only one vertical. A large Darrieus is nevertheless holding its own in the rather unexpected application of irrigation, as described in some notes on a field trip to a USDA research centre, in spite of apparent horizontal-axis predominance and of a certain amount of sniping from advocates of the straight-blade vertical-axis machine. The latter continues to generate nomenclature, if not power; we now have the Giromill and the Cycloturbine using similar principles of cyclic pitch control, although the Giromill failed to work in its synchronous mode and the Cycloturbine preferred modest success on DC. The continuing interest in synchronous machines is noteworthy in the light of recent developments in frequency conversion systems for constant TSR turbines, described by G W-W Pontin at the Seminar on UK Wind Power in July.

Subsidiary technologies were represented by useful papers on pasted-plate lead-acid batteries for storage, analysis and testing of a tower structure, and a composite bearingless rotor concept.

- TJ Wolff, Ben.  
825 Wind energy / Ben Wolff, Hans Meyer. --  
.W86 Philadelphia : Franklin Institute Press,  
c1978.  
82 p. : ill.  
Bibliography: p. 73-74.  
ISBN 0-89168-004-7  
1. Wind power. I. Meyer, Hans Klaus,  
joint author. II. Title.

NASA CP-2034 Windmill blades

1978

WIND TURBINE STRUCTURAL DYNAMICS. Dean R. Miller, LeRC, ed. (Workshop sponsored by DOE and held LeRC, Nov. 15-17, 1977). Mar. 1978. 290p.

(CONF-771148--), pp 227-236) Effects of rotor location, coning, and tilt on critical loads in large wind turbines. Spera, D.A., Janetzke, D.C. (Lewis Research Center, Cleveland). 1978

From Wind turbine structural dynamics conference, Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

Three large (1500 kW) horizontal rotor configurations were analyzed to determine the effects on dynamic loads of upward and downwind rotor locations, coned and radial blade positions, and tilted and horizontal rotor axis positions. Loads were calculated for a range of wind velocities at three locations in the structure: the blade shank, the hub shaft, and the yaw drive. Blade axis coning and rotor axis tilt were found to have minor effects on loads. However, locating the rotor upwind of the tower significantly reduced loads at all locations analyzed.

A78-38972 Fundamentals of wind energy. N. P. Cheremisinoff (Union Camp Corp., Princeton, N.J.). Ann Arbor, Mich., Ann Arbor Science Publishers, Inc., 1978. 173 p. 93 refs. \$6.95.

The book presents a broad overview of the fundamental principles and applications of wind energy systems. The historical development of wind machines is outlined. Several applications of wind energy are identified such as agricultural uses, rural and municipal uses, projects involving pumping and compressed gas, and large-scale energy production. Further consideration is given to wind machines and generators, noting horizontal-axis rotors, vertical-axis rotors, and cross-wind horizontal-axis rotors. The performance and design characteristics of wind energy systems are discussed and economic factors are identified. The major aspects influencing the selection of sites for wind-energy systems are presented. Systems for energy storage are proposed, including electrochemical, thermal, and mechanical energy storage.

A78-40841 Improvement of windmill efficiency by boundary layer control. J. S. Montes (Tasmania, University, Hobart, Australia). Wind Engineering, vol. 2, no. 2, 1978, p. 103-114. 7 refs.

The desirability of using boundary layer suction to increase the efficiency of conventional windmills is discussed. The rotation of the windmill blades provides a source of internal flow which can be utilized as a simple pump for the boundary layer suction, and a simplified mathematical model of the internal flow is presented. Equations are integrated numerically for some assumed values of the windmill geometrical parameters, and it is shown that, if certain conditions are assumed, advantages of some 20% in the operational efficiency of a variable pitch windmill and 33% for the fixed-pitch windmill can be obtained.



DETERMINATION OF OPTIMUM ARRAYS OF WIND  
ENERGY CONVERSION DEVICES.

G. M. Bragg & W. L. Schmidt

Journal of Energy, Vol. 2, No. 3, May/June  
1978, p. 155-159.

**T**HE introduction of arrays of wind energy machines will provide for the conversion of sizable amounts of renewable energy resources into high-grade energy. In this paper, we shall outline a model to predict the performance of such arrays based on a rough boundary-layer velocity profile.

The model attempts to predict atmospheric boundary-layer velocity profiles within an array of full-scale systems from turbulent boundary-layer flow profiles within passive discrete roughness elements located on a rough surface. This allows us to draw on a large body of rough boundary-layer literature to carry out the array performance optimization analysis. Ideally, such arrays would be located on large open regions, either inland or just offshore. Although these regions may not enjoy the most energetic winds, they provide good potential for large-scale wind energy development.

NASA CP-2034 Windmill blades

1978

**WIND TURBINE STRUCTURAL DYNAMICS.** Dean R. Miller, LeRC, ed. (Workshop sponsored by DOE and held LeRC, Nov. 15-17, 1977). Mar. 1978. 290p.

(CONF-771148—, pp 61-69) Aeroelastic stability of wind turbine blades. Kaza, K.R.V. (Univ. of Toledo). 1978.

71148

From Wind turbine structural dynamics conference; Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

-17.

The second-degree nonlinear aeroelastic equations for a flexible, twisted, non-uniform wind turbine blade are developed using Hamilton's principle. The derivation of these equations has its basis in the geometric nonlinear theory of elasticity. These equations with periodic coefficients are suitable for determining the aeroelastic stability and response of large wind turbine blades. Methods for solving these equations are discussed.

NONLINEAR DYNAMIC RESPONSE OF A WIND TURBINE ROTOR  
UNDER GRAVITATIONAL LOADING.

I. Chopra and J. Dugundji.

AIAA J., v.16, no.8, Aug. 1978, p.773-74.

NASA CP-2034 Windmill blades

1978

**WIND TURBINE STRUCTURAL DYNAMICS.** Dean R. Miller, LeRC, ed. (Workshop sponsored by DOE and held LeRC, Nov. 15-17, 1977). Mar. 1978. 290p.

(CONF-771148—, pp 257-260) Research of low cost wind generator rotors. Fertis, D.G. (Univ. of Akron, OH); Ross, R.S. 71148

1978. From Wind turbine structural dynamics conference; Cleveland, OH, USA (15 Nov 1977).

-17.

In Wind turbine structural dynamics.

This feasibility program determined that it would be possible to significantly reduce the cost of manufacturing wind generator rotors by making them of cast urethane. Goodyear developed several high modulus urethanes which were structurally tested at the University of Akron. A section of rotor was also cast and tested showing the excellent aerodynamic surface which results. A design analysis indicated that a cost reduction of almost ten to one can be achieved with a small weight increase to achieve the same structural integrity as expected of current rotor systems.

NASA CP-2034 Windmill blades

1978

**WIND TURBINE STRUCTURAL DYNAMICS.** Dean R. Miller, LeRC, ed. (Workshop sponsored by DOE and held LeRC, Nov. 15-17, 1977). Mar. 1978. 290p.

(CONF-771148—, pp 237-242) Comparison of blade loads of fixed and free yawing wind turbines. Cheney, M.C.; Bielawa, R.L. 71148

(United Technologies Research Center, East Hartford, CT). 1978. From Wind turbine structural dynamics conference; Cleveland, OH, USA (15 Nov 1977).

-17.

In Wind turbine structural dynamics.

The UTRC Self Regulating Composite Bearingless Wind Turbine utilizes an automatic pitch control concept and a completely unrestrained yawing degree of freedom. Aerodynamic moments caused by skewed flow provide the control to align the wind turbine with the wind. Model tests have demonstrated the feasibility of the concept and analytical studies have shown the free system to experience lower blade loads compared to the fixed system.

36221 Wind: bibliography. Alward, R. (comp.). Butte, MT; National Center for Appropriate Technology (1978). 8p. (NP-23683).

A bibliography of books, pamphlets, proceedings, periodicals, plans, and access bibliographies is presented concerning wind power and wind turbine equipment.

FLUID DYNAMICS OF DIFFUSER-AUGMENTED WIND TURBINES,  
by Barry L. Gilbert, Richard A. Oman, and Kenneth  
M. Foreman.  
Journal of Energy, vol. 2, no. 6, Nov.-Dec. 1978,  
p. 368-374.

The diffuser-augmented wind turbine (DAWT) is one of the advanced concepts being investigated to improve the economics of wind energy conversion systems (WECS). Application of modern boundary-layer control techniques has reduced the surface area requirements of an efficient diffuser by an order of magnitude. Many parameters that affect the performance of the diffuser system have been examined in small-scale wind tunnel tests with a family of compact diffusers, using screens and centerbodies to simulate the presence of a turbine. Flowfield surveys, overall performance, the effect of ground proximity, and the prospects for further improvement are described. The baseline configuration is a conical, 60 deg included angle diffuser with an area ratio of 2.78 controlled by two tangential injection slots. This first-generation DAWT can provide about twice the power of a conventional WECS with the same turbine diameter and wind. Economic estimates show that this DAWT can be as much as 50% cheaper than conventional WECS for the same rated power.

A78-53863 Short-term storage and wind power availability. M. B. Anderson, K. Newton, M. Ryle, and P. F. Scott (Cambridge University, Cambridge, England). *Nature*, vol. 275, Oct. 5, 1978, p. 432-434. 6 refs. Research supported by the Science Research Council and Royal Commission for the Exhibition of 1851.

Hourly wind and temperature measurements over a 17-yr period were used to investigate the feasibility of a simple system in which wind power is used in conjunction with 150-hour thermal storage for providing domestic space heating for the U.K. The model system consists of connected turbines providing the sole means of heating for three groups of houses, each house being equipped with a thermal store having a half power decay time of 150 hours. It was found that the temperature in the houses is kept within 3 C of the nominal temperature of 20 C for 86% of the time. It is shown that use of too high a rated speed (wind speed at which turbine produces peak output) leads to large fluctuations in available power and could result in more expensive design of turbine for a given annual energy output.

P.T.H.

## WIND-ELECTRIC CONVERSION UTILIZING FIELD MODULATED GENERATOR SYSTEMS

R. Ramakumar

Solar Energy, v.20, no.2, 1978, p. 109-117.

This paper describes wind-electric conversion systems utilizing field modulated generators[16]. Schemes to integrate such systems with conventional utility grids are also discussed.

A78-49840 Optimum design point geometry and performance of propeller type wind turbines. N. H. Juul (New York, State University, Buffalo, N.Y.). *Wind Engineering*, vol. 2, no. 2, 1978, p. 86-102. 6 refs.

The simple strip theory is used to develop the equations which are required to determine the optimum design point geometry and performance parameters of propeller type wind turbines. The optimum design point is defined by the conditions which maximize the power absorbed by each blade element along the blade. A computer program is developed to calculate, for a given airfoil, the dimensionless optimum design point performance. The behavior of the important local and total turbomachinery parameters are studied. The range of tip speed ratios for which the strip theory is applicable is determined. The effects of viscosity, compressibility and tip losses are investigated. As an example, the results for wind turbines with NACA 4312 blades are presented graphically. These graphs may be used to choose the design point best suited for a desired application.

(Author)

MASA CP-2034 Windmill blades

1978

WIND TURBINE STRUCTURAL DYNAMICS. Dean R. Miller, LeRC, ed. (Workshop sponsored by DOE and held LeRC, Nov.15-17,1977). Mar.1978. 290p.

Department of Energy,  
Washington, D.C.  
Workshop on Wind Turbine  
Structural Dynamics

CONF-771148

Nov.15-17,  
1977

(CONF-771148—, pp 265-268) UMass wind furnace blade design. Cromack, D.E. (Univ. of Massachusetts, Amherst). 1978.

From Wind turbine structural dynamics conference; Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

A brief description of the UMass Wind Furnace concept is presented along with some preliminary performance data. Particular emphasis is placed on the design, construction, and manufacturing procedure for the 32.5 foot diameter GRP blades.

N80-11578# Department of Energy, Washington, D. C. Office of Solar, Geothermal, Electric and Storage Systems.

WIND ENERGY SYSTEMS: PROGRAM SUMMARY

Dec 1978 134 p refs

(DOE/ET 0093) Avail: NTIS HC A07/MF A01

Projects to develop reliable and economically viable wind energy systems and enable the earliest possible commercialization of wind power are described. The program's general organization is also described.

DOE

TJ  
153 Energy Technology Conference, 5th, Washington,  
D.C., 1978.

.E4787 Energy technology V : challenges to  
1978 technology : proceedings of the fifth  
Energy Technology Conference, February 27-  
March 1, 1978, Washington, D.C. / edited by  
Richard F. Hill. -- Washington : Government  
Institutes, 1978.

#### LARGE WIND TURBINE GENERATORS

Ronald L. Thomas, Richard M. Donovan, NASA-Lewis Research Center

p.64

The Federal Wind Program was initiated in 1973 as a part of the nation's solar energy program. The first wind energy workshop was held in 1973 (Ref. 1) to review past work in wind energy and to assess the potential of wind power. From this workshop it became evident that it was desirable to test a representative large wind turbine as quickly as possible to provide engineering data for use as a base for the entire wind energy program. During FY 1974 a 5-year wind energy program plan was developed as part of the Solar Energy Plan of the Project Independence Blueprint (Ref. 2). This wind energy program included the 1973 workshop recommendation to proceed with the design, building and testing of a nominal 100 kW, 125-foot-diameter rotor wind turbine; this wind turbine was designated Mod-0.

A COMPARISON OF THE WEIBULL AND RAYLEIGH DISTRIBUTIONS  
FOR ESTIMATING WIND POWER POTENTIAL, by Joseph P.  
Hennessey, Jr.

Wind Engineering, vol. 2, no. 3, 1978, p. 156-164.

*For potential wind power sites where the Weibull model of the wind speed distribution is applicable, some general guidance is provided which will help investigators decide 1) whether or not the Rayleigh distribution will be a satisfactory approximation to the Weibull, 2) which sites are the most productive and reliable for an aerogenerator of a specific size, and 3) which size of aerogenerator should be used given the wind speed characteristics of a certain site.*

N78-32719# Sandia Labs., Albuquerque, N. Mex.

#### AVAILABILITY OF WIND POWER

J. W. Reed 1978 15 p refs Presented at Seminar on Wind  
Energy for Electrical Generation, Recife, Brazil, 13-16 Feb.  
1978

(Contract EY-76-C-04-0789)

(SAND-78-0548C; Conf-780253-1)

Avail: NTIS

HC A02/MF A01

Meteorological studies of available wind power to support  
the development of a vertical-axis wind turbine are presented  
and reviewed. Climatological studies that are needed to assist  
and promote wind energy exploitation in Brazil are summarized.

DOE

#### PROBABILITY MODELS OF WIND VELOCITY MAGNITUDE AND PERSISTENCE.

Ross B. Corotis, Arden B. Sigl, & Joel Klein  
Solar Energy, Vol. 20, No. 6, 1978, p. 483-  
493.

**Abstract**—Hourly wind data from the National Climatic Center are used to study probability density functions of wind velocity and wind power and run duration persistence. Observed histograms of velocity are compared with the  $\chi^2$  and Weibull distributions using goodness-of-fit statistics, and wind power histograms are compared with distributions derived from these. From an engineering standpoint, the observed histograms compare well with the models, although discrepancies exist. Over the power ranges of interest for wind energy conversion, taking into account the effects of wind generator response characteristics (cut-in, feathering, etc.), the models appear promising. Velocity run duration histograms above and below fixed levels are constructed and compared with both an exponential and power law persistence model. Calibrating the exponential model from the observed mean duration leads to reasonable estimates for the longer runs. A simplified technique of scaling the power law model from the mean seasonal velocity at a site gives good run duration estimates, except for the longer runs.

CN-150,831, v.4 1978  
WIND ENERGY CONVERSION. VOLUME IV: DRIVE  
SYSTEM DYNAMICS. M. Martinez-Sanchez and  
T. Labuszewski. Sept.1978. 191p.

Massachusetts Inst. of Tech., ASRL-TR-184-10  
(Cambridge), Aeroelastic  
and Structures Research Lab.  
Contract E(11.1)-4131

Windmills  
Windmill blades

#### THE EFFECT OF HUB FAIRINGS ON WIND TURBINE ROTOR PERFORMANCE.

R. E. Wilson

Transactions of the ASME: Journal of Fluids  
Engineering, Vol. 100, No. 1, March 1978, p. 120  
-135

Hub fairings or spinners are frequently suggested for wind turbines for reasons of aesthetics or performance. While hub fairings rarely, if ever, decrease the appearance of a wind turbine, the effects of a nose fairing may actually decrease rather than increase wind turbine rotor performance.



## SOLAR POLICY REVIEW.

Wind Power Digest, no. 14, Winter 1978, p.8

Options for wind energy funding and policy

On May 1, 1978, President Jimmy Carter announced a major cabinet-level review of U.S. solar energy policy. Termed the Domestic Policy Review (DPR), the program initiated large public meetings throughout the country with thousands of people testifying in support of expanded federal efforts in the solar energy field. One of the final public exercises of the DPR was a "Public Meeting on Solar Technology" held in Washington D.C. on August 8-9, 1978. The meeting was called by Bennett Miller, the then newly-appointed Assistant Secretary for Energy Technology.

Experts in all solar technologies were invited to participate in a budget preparation exercise for each of 8 separate technologies. The panel assigned the task of reviewing wind energy budget policies was headed by Rick Katzenberg, past president of the American Wind Energy Association. What follows is his final report to Bennett Miller and the other Department of Energy officials involved in the Domestic Policy Review.

## CALCULATION OF THE GEOMETRY AND PERFORMANCE OF A HIGHSPEED WIND ROTOR.

Yves Mercadier

Wind Engineering, Vol. 2, No. 1, 1978, p. 25-36.

Wind rotor design has hitherto been based, particularly for lower powers, upon a compromise between high efficiency and simplicity of construction. Modern materials and fabrication techniques, however, permit the elimination of this compromise and the construction of rotors of maximum efficiency.

The primary consideration in a wind power installation being the proportion of energy extracted from the wind rather than the actual power output, it becomes necessary to assess the performance of the turbine over its whole range of operating conditions. It is then possible to design a transmission system appropriate to the function of the installation and to specify operating limits. This sequence depends upon the accurate initial calculation of rotor geometry and performance.

CM-150,831, v.8

1978

WIND ENERGY CONVERSION. VOLUME VIII: FREE WAKE ANALYSIS OF WIND TURBINE AERODYNAMICS.

Jean-Claude Bohard and Song Y. Chung. Sept. 1978. 294p.

Massachusetts Inst. of Tech., ASRL-TR-184-14  
(Cambridge), Aeroelastic  
and Structures Research Lab.  
Contract E(11.1)-4131

Windmills

Windmill blades

N78-27528\*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena  
WIND ENERGY SYSTEMS

Homer Joe Stewart In its Proc. of the Alternate Energy Systems Seminar 30 Mar. 1978 p 150-170 (For primary document see N78-27522 18-44)

Avail: NTIS HC A09/MF A01 CSCL 10A

A discussion on wind energy systems involved with the DOE wind energy program is presented. Some of the problems associated with wind energy systems are discussed. The cost, efficiency, and structural design of wind energy systems are analyzed.

G Y

N78-27529\*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena  
SYSTEM CONSIDERATIONS

M. E. Alper In its Proc. of the Alternate Energy Systems Seminar 30 Mar. 1978 p 171-177 (For primary document see N78-27522 18-44)

Avail: NTIS HC A09/MF A01 CSCL 10A

Closing remarks and a general summary of the Alternative Energy Systems Seminar are presented. It was concluded from the seminar that the DOE programs described were focused on trying to make a commercial market develop for the various systems. The question addressed is how this is going to happen. To address this question, social, economical, political and technical aspects are considered with major emphasis placed on systems engineering to provide low cost efficient systems.

G Y

## HARNESSING THE WIND.

James T. Yen

IEEE Spectrum, Vol. 15, no. 3, March 1978, p42-47

Various types of wind turbines are compared. Economic aspects of wind turbines are considered. Special attention is given to the tornado-type wind turbine.

TA National SMPF Symposium and Exhibition, 23rd,  
 118.9 Anaheim, Calif., 1978.  
 .C6 Selective application of materials for  
 A3 products and energy ... cl979.  
 1978 (Card 2)

Includes bibliographical references and  
 index.

1 Materials--Congresses. I. Society  
 WIND-TURBINE-GENERATOR ROTOR-BLADE CONCEPTS WITH LOW-COST 428  
 POTENTIAL

T. L. Sullivan, T. P. Cahill, D. G. Griffie, Jr. and  
 H. W. Gewehr

A78-49950 A low cost aerodynamic heater representing a  
 fully matched load for wind energy systems. M. O. Lawson (Dayton,  
 University, Dayton, Ohio). In: NAECON '78; Proceedings of the  
 National Aerospace and Electronics Conference, Dayton, Ohio, May  
 16-18, 1978. Volume 2. (A78-49851 22-04) New York, Institute of  
 Electrical and Electronics Engineers, Inc., 1978, p. 874-880.

The aerodynamic heater described operates on fluid dynamic  
 principles as does the wind turbine. This relation makes it possible to  
 operate the wind turbine at its optimum tip speed to wind velocity  
 ratio up to the wind turbine's rate value. The heater resembles a  
 centrifugal blower shaped like a disk 12 inches in diameter by  
 4 inches thick. A sketch is provided of a heater which consists of a  
 sheet metal case having an air intake port at the center of one  
 circular face, and an air outlet along the perimeter. An internal rotor  
 with blades around its circumference, an internal toroidal air passage  
 with stator blades, and a variable outflow butterfly valve to regulate  
 temperature are the other components. The aerodynamic heater  
 system may consist of a fixed-pitch wind turbine mounted on a  
 tower along with a step-up transmission to match the torque  
 characteristics of the wind turbine and the heater. G.R.

SOLAR ENERGY: UNSUNG POTENTIAL FOR WIND AND BIOMASS  
 W.D.M.  
 Science, vol. 200, no. 4342, May 12, 1978, p.636

Government-sponsored studies seem to be converging  
 toward the conclusions that solar power could supply sub-  
 stantially more than 1 to 2 percent of the country's energy  
 by 2000, and that the most promising types of solar energy  
 are ones that have been largely unheralded.

CN-150,831, v.1 1978  
 WIND ENERGY CONVERSION. VOLUME I: METHODS FOR  
 DESIGN ANALYSIS OF HORIZONTAL AXIS WIND TURBINES.  
 R.H. Miller, J. Dugundji, M. Martinez-Sanchez,  
 et al. Sept.1978. 253p.

Massachusetts Inst. of Tech., ASRL-TR-184-7  
 (Cambridge), Aeroelastic  
 and Structures Research Lab.  
 Contract E(11.1)-4131

Wind mills  
 Windmill blades

A79-31425 Wind power from a vortex chamber. P. N.  
 Wang (Toronto, University, Toronto, Canada) and I. Huang (National  
 Tsing Hua University, Hsinchu, Nationalist China). In: Renewable  
 alternatives; Proceedings of the Fourth Annual Conference, London,  
 Ontario, Canada, August 20-24, 1978, Volume 1. (A79-31401 12-44)  
 Winnipeg, Solar Energy Society of Canada, Inc., 1978. 9 p. 12 refs.  
 National Science Council of Nationalist China Contract No. 65E-  
 0401-03(03).

In the utilization of wind energy, one of the major difficulties is  
 the problem of low wind energy density. A new wind energy system  
 employing the concept of confined vortex flow was proposed by Yen  
 (1975, 1976, 1977) to overcome this difficulty. The new system,  
 which is called tornado-type wind energy system, makes use of  
 pressure energy. This energy is developed by utilizing the pressure  
 difference between the ambient flow and the core of the confined  
 vortex flow. The reported study has the objective to further  
 investigate the feasibility of the considered approach. The pressure  
 energy of the confined vortex flow is studied on the basis of a model  
 test in the wind tunnel. G.R.

A VISIT WITH ASTRAL-WILCON, by Bill Sheperdson.  
 Wind Power Digest, no. 14, Winter 1978, p.36-38.

Astral Wilcon, Inc. ventured into the public eye for  
 the first time at the recent AWEA Conference and Ex-  
 position held in Hyannis, Massachusetts on Cape Cod in  
 late September, 1978. As it turned out, Astral was of one  
 of the few companies that arranged an impressive  
 outdoor display. On display was Astral's newly  
 developed prototype windturbine generator (WTG), the  
 AW 10-B, which is 26 feet in rotor diameter and is  
 designed to produce 10kW in a 22 mph wind.

## ESTIMATING WIND ENERGY

David Simms

Alternative Sources of Energy  
Vol. no. 30 February 1978

p. 27-31

The figures which will be discussed here are pertinent to our particular area in southern Quebec. The aim is not to answer the question which anyone would have about the potential viability of wind power in his area, but to discuss a method of using existing wind speed data and the power curves of various wind machines to estimate the likely output.

**A79-20828 \*** Wind-turbine-generator rotor-blade concepts with low-cost potential. T. L. Sullivan, T. P. Cahill (NASA, Lewis Research Center, Cleveland, Ohio), D. G. Griffie, Jr. (NASA, Lewis Research Center, Cleveland, Ohio; United Technologies Corp., Hamilton Standard Div., Windsor Locks, Conn.), and H. W. Gewehr (NASA, Lewis Research Center, Cleveland, Ohio; Kaman Aerospace

Corp., Bloomfield, Conn.). In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 428-456.

Four processes for producing blades are examined. Two use filament winding techniques and two involve filling a mold or form to produce all or part of a blade. The processes are described and a comparison is made of costs, material properties, designs and free vibration characteristics. Conclusions are made regarding the feasibility of each process to produce low-cost, structurally adequate blades.

**A78-42419** Calculation of the geometry and performance of a high-speed wind rotor. Y. Mercadier (Sherbrooke, Université, Sherbrooke, Quebec, Canada). *Wind Engineering*, vol. 2, no. 1, 1978, p. 25-36.

Methods of calculating rotor geometry and rotor performance are presented. The procedure involves blade element theory combined with conservation principles applied to flow through a disk. Calculated data on rotor performance efficiency as a function of the operating parameter, power as a function of wind speed and rotational speed, and shaft torque as a function of wind speed and rotational speed are presented. It is suggested that modern materials and fabrication techniques permit the construction of rotors of maximum efficiency. Successful design requires assessment of the performance over the whole range of operating conditions. M.L.

**A78-20786 #** Land contouring to optimize wind power. S. E. Fuhs, A. E. Fuhs, and G. N. Vanderplaats (U.S. Naval Postgraduate School, Monterey, Calif.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 16th, Huntsville, Ala., Jan. 16-18, 1978, Paper 78-279*, 9 p. 7 refs.

Certain locations on a hill have higher local wind velocity than the freestream value. The augmentation of wind power depends on the shape of the hill. Using numerical optimization techniques, the optimum shape has been determined for several different constraints. Knowledge of the optimum shape is valuable for two reasons. First, the site selection is aided if the best contour is known; near optimum shapes may occur naturally. Second, for a given site, the excavation and fill necessary to achieve optimum shape can be determined. Four cases are discussed. Each case had different constraints and yielded different values of wind power augmentation as follows: Case 1, 226 percent; Case 2, 311 percent; Case 3, 210 percent; and Case 4, 156 percent. (Author)

**A79-20627 \*** Fatigue impact on Mod-1 wind turbine design. C. V. Stahle, Jr. (General Electric Co., Space Div., Valley Forge, Pa.). In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 417-427. Contract No. NAS3-20058.

Fatigue is a key consideration in the design of a long-life Wind Turbine Generator (WTG) system. This paper discusses the fatigue aspects of the large Mod-1 horizontal-axis WTG design starting with the characterization of the environment and proceeding through the design. Major sources of fatigue loading are discussed and methods of limiting fatigue loading are described. NASTRAN finite element models are used to determine dynamic loading and internal cyclic stresses. Recent developments in determining the allowable fatigue stress consistent with present construction codes are discussed relative to their application to WTG structural design. (Author)

**A78-30745** The earth as a solar heat engine. J. Kenton (Electric Power Research Institute, Palo Alto, Calif.). *EPRI Journal*, vol. 3, Mar. 1978, p. 43-48.

The utilization of indirect solar energy sources is discussed. New developments concerning the employment of wind power are partly related to research conducted by NASA working in cooperation with DOE. The huge airfoil blades on which modern wind-power machines are based are mounted with variable-pitch gears so that the blade angle of attack can be varied to obtain optimal aerodynamic efficiency over a range of wind speeds. The federal wind energy program covers five areas, including program development and technology, small machines for farm and rural use, 100-kilowatt-scale systems, megawatt-scale systems, and large multiunit systems. Attention is also given to wind power problems, approaches for utilizing wave power, techniques for ocean-thermal conversion, tidal power problems, and the prospects of biomass conversion. G.R.

**A78-22612 #** Experimental and analytical studies of the aerodynamic performance of windmills. R. L. Figard and J. A. Schetz (Virginia Polytechnic Institute and State University, Blacksburg, Va.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 16th, Huntsville, Ala., Jan. 16-18, 1978, Paper 78-277*, 8 p. 9 refs. Research supported by the U.S. Department of Agriculture.

The aerodynamic performance of a modern, high tip speed, three-bladed windmill rated at 10 kW at 30 mph was studied by three methods. First, the results of field tests of the actual device with both a resistive and a battery-charging electric load are reported. Second, the predictions of a simple blade element analysis are presented and compared with the field data. Aerodynamic blade section coefficients of an actual blade section were measured in a wind tunnel and used as input in the analysis. Third, wind tunnel test results for a 1/5th scale model are given. Reynolds number simulation from model to prototype is considered in detail. Finally, the results of all three efforts are compared. (Author)

**A78-34512** Diffuser augmentation of wind turbines. K. M. Foreman, B. Gilbert, and R. A. Oman (Grumman Fluid Dynamics Laboratory, Bethpage, N.Y.). *Solar Energy*, vol. 20, no. 4, 1978, p. 305-311, 10 refs. Contract No. E(11-1)-2616.

The theory of diffuser augmentation is described, and the wind tunnel investigation of models of two diffuser design concepts is considered in an economic analysis of diffuser-augmented turbines (DAWT). One design concept involves the use of the energetic external wind to prevent separation of the diffuser's internal boundary layer, while the other method uses high-lift airfoil contours for the diffuser wall shape. Diffuser model tests indicate almost a doubling of wind power extraction capability for DAWT in comparison with conventional turbines. Economic studies (1975 cost projections) suggest that the specific power costs for a realistic DAWT configuration are lower than the costs for conventional wind turbines for rotors with diameters over 50 m or less than 20 m. M.L.

**A79-31427** The Prince Edward Island Wind Energy Program. M. Lodge (Institute of Man and Resources, Charlottetown, Prince Edward Island, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978, 13 p. 5 refs.

A description is presented of investigations related to the development of wind as a renewable and sustainable energy source in the Province of Prince Edward Island. The considered research and development program, which commenced in July 1977, is composed of four elements related to wind data, the integration of large Wind Energy Converter Systems (WECS), rural and farm applications of small WECS, and investigations conducted at an Atlantic wind test site. The analysis of the data obtained so far suggests that winds at exposed coastal locations in the Province of Prince Edward Island are sufficiently high to warrant the continued development and testing of a prediction model. G.R.



CN-150,831, v.2 1978  
**WIND ENERGY CONVERSION. VOLUME II: AERODYNAMICS  
 OF HORIZONTAL AXIS WIND TURBINES.** R.H. Miller,  
 J. Dugundji, M. Martinez-Sanchez, et al. Sept.  
 1978. 209p.

Massachusetts Inst. of Tech., ASRL-TR-184-8  
 (Cambridge), Aeroelastic  
 and Structures Research Lab.  
 Contract E(11.1)-4131

## Windmills Windmill blades

A79-10234 \* Design and operating experience on the U.S.  
 Department of Energy Experimental Mod-O 100 kW Wind Turbine.  
 J. C. Glasgow and A. G. Birchenough (NASA, Lewis Research  
 Center, Cleveland, Ohio). In: Intersociety Energy Conversion Engi-  
 neering Conference, 13th, San Diego, Calif., August 20-25, 1978,  
 Proceedings. Volume 3. (A79-10001 01-44) Warrendale, Pa., Society  
 of Automotive Engineers, Inc., 1978, p. 2052-2059. 5 refs.

The Mod-O 100 kW Experimental Wind Turbine was designed  
 and fabricated by NASA, as part of the Federal Wind Energy  
 Program, to assess technology requirements and engineering prob-  
 lems of large wind turbines. The machine became operational in  
 October 1975 and has demonstrated successful operation in all of its  
 design modes. During the course of its operations the machine has  
 generated a wealth of experimental data and has served as a  
 prototype developmental test bed for the Mod-OA operational wind  
 turbines which are currently used on utility networks. This paper  
 describes the mechanical and control systems as they evolved in  
 operational tests and describes some of the experience with various  
 systems in the downwind rotor configuration. (Author)

## Proceedings of the Third Biennial Conference and Workshop on Wind Energy Conversion Systems. Volume II.

T. R. Kornreich.  
 JBF Scientific Corp., Wilmington, MA. May 78. 496p  
**CONF-770921-P2** Price code: PC A21/MF A01

Separate abstracts are included for 34 papers presented  
 concerning technology development, meteorological siting  
 considerations, multi-unit applications, and innovative and  
 advanced systems concepts. Two papers were previously  
 input into the energy data base. (ERA citation 03:056814)

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National ASME Symposium and Exhibition, 23rd,  
 Anaheim, Calif., 1978.

Selective application of materials for  
 products and energy / Society for the  
 Advancement of Material and Process Engi-  
 neering. — Azusa, Calif. : Society for the  
 Advancement of Material and Process Engi-  
 neering, c1978.

WIND-TURBINE-GENERATOR ROTOR-BLADE CONCEPTS WITH LOW-COST  
 POTENTIAL

428

T. L. Sullivan, T. P. Cahill, D. G. Griffie, Jr. and  
 H. W. Gewehr

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A79-14719 Wind, waves, and tides. M. F. Merriam (Cali-  
 fornia, University, Berkeley, Calif.). In: Annual review of energy.  
 Volume 3. (A79-14718 03-44) Palo Alto, Calif., Annual Reviews,  
 Inc., 1978, p. 29-56. 56 refs.

Wind, waves, and tides are of interest today as possible future  
 energy sources primarily because of their nondepletable character  
 and their favorable environmental aspect, in comparison with energy  
 technologies presently in use. Studies comparing the cost of energy  
 often have difficulties making a case for immediate economic  
 viability of the renewable sources. If, however, oil and gas resources  
 of the world do in fact become progressively and substantially

depleted over the next 25 years, price increases and shortages will  
 ensue and implementation of presently uneconomic alternatives will  
 occur on a large scale. A review is presented of the present state of  
 knowledge and experience with wind, wave, and tidal energy. The  
 power density in the wind may, at a good site, average some  
 hundreds of watts per square meter. Wave power being transported  
 across a plane perpendicular to the wave propagation direction, at a  
 good site, is from 10-100 times as large. Questions concerning the  
 value of energy from an intermittent source are also considered. G.R.

A78-32074

Winds and wind system performance. C. G.  
 Justus (Georgia Institute of Technology, Atlanta, Ga.). Research  
 supported by the National Science Foundation and Energy Research  
 and Development Administration. Philadelphia, Pa., Franklin Insti-  
 tute Press, 1978. 120 p. 94 refs. \$6.50.

Wind characteristics are discussed with reference to evaluation  
 of wind energy conversion systems performance. Weather data  
 sources and measurement methods are considered, and techniques  
 applicable to large-scale (e.g., large multi-unit arrays) and to small  
 scale (e.g., simple power regression relations) use are described.  
 Calculation of output power is explained, factors relevant to system  
 design, siting, and operation are taken into account, and special  
 requirements necessary for performance evaluation are reported.

M.L.

#### ON VORTEX WIND POWER.

Ronald M. C. SO

Transactions of the ASME: Journal of Fluids Engineering, Vol. 100, No. 1, March 1978, p. 79-92

*An infinite viscous laminar vortex with no reverse flow region in the exit plane, but with axial inflow at the base, is analyzed. The axial inflow is assumed to be finite everywhere. From the analysis, the maximum wind power that can be obtained from such a vortex is calculated. The results show that the power developed depends on the circulation at infinity and on the viscous radius of the core of the vortex. The significance of this result, as it relates to the recently proposed vortex wind energy system, is discussed.*

A79-20826 \*

Wind turbine generator application places unique demands on tower design and materials. J. P. Kita (General Electric Co., Space Div., Valley Forge, Pa.). In: Selective application of materials for products and energy. Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 24, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 409-416. Contract No. NAS3 20058.

The most relevant contractual tower design requirements and goal for the Mod-1 tower are related to steel truss tower construction, cost effective state-of-the-art design, a design life of 30 years, and maximum wind conditions of 120 mph at 30 feet elevation. The Mod-1 tower design approach was an iterative process. Static design loads were calculated and member sizes and overall geometry chosen with the use of finite element computer techniques. Initial tower dynamic characteristics were then combined with the dynamic properties of the other wind turbine components, and a series of complex dynamic computer programs were run to establish a dynamic load set and then a second tower design. G.R.

#### WIND POWER LIMITATIONS ASSOCIATED WITH VORTICES.

J.L. Loth.

J. Energy, v.2, no.4, July-Aug.1978, p.216-222.

In the search for smaller and more powerful wind machines, the use of a vortex to create a region of low pressure and high velocity has been considered by several investigators. The theoretical maximum power coefficient of two vortex-ingesting wind turbine configurations have been computed. In addition, two wind turbine configurations which use the low pressure in the vortex core to exhaust into have also been analyzed.

CM-150,831, v.3

1978

WIND ENERGY CONVERSION. VOLUME III: DYNAMICS OF HORIZONTAL AXIS WIND TURBINES. R. Miller, J. Dugundji, I. Chopra, et al. Sept.1978. 145p.

Massachusetts Inst. of Tech., ASRL-TR-184-9  
(Cambridge), Aeroelastic  
and Structures Research Lab.  
Contract E(11.1)-4131

#### Windmills

#### Windmill blades

N78-29583# National Aeronautics and Space Administration  
Lewis Research Center, Cleveland, Ohio.

#### THE 200-KILOWATT WIND TURBINE PROJECT

Jan. 1978 17 p refs Prepared for DOE

(NASA-TM-79757) Avail NTIS HC A02/MF A01 CSCL 10B

The three 200 kilowatt wind turbines described, compose the first of three separate systems. Proposed wind turbines of the two other systems, although similar in design, are larger in both physical size and rated power generation. The overall objective of the project is to obtain early operation and performance data while gaining initial experience in the operation of large, horizontal axis wind turbines in typical utility environments. Several of the key issues addressed include the following: (1) impact of the variable power output (due to varying wind speeds) on the utility grid (2) compatibility with utility requirements (voltage and frequency control of generated power) (3) demonstration of unattended, fail-safe operation (4) reliability of the wind turbine system (5) required maintenance and (6) initial public reaction and acceptance. L.S.

#### WIND SHEAR FLUCTUATIONS DOWNWIND OF LARGE SURFACE ROUGHNESS ELEMENTS

J. V. Ramsdell

Journal of Applied Meteorology, vol. 17,  
no. 4, p.436-443, 1978

The purpose of this paper is to describe some of the spatial variability observed in a recent measurement program (Ramsdell, 1975) that might be useful in WECS design. In particular, the variations of the vertical and lateral shear of the longitudinal wind component will be described.

## WIND-ELECTRIC CONVERSION UTILIZING FIELD-MODULATED GENERATOR SYSTEMS.

R. Ramakumar.

School of Electrical Engineering, Oklahoma State University, Stillwater, OK 74074, U.S.A.

*Solar Energy*. 1978, Vol.20, 2, 109-117.

Variable-speed constant-frequency wind electric systems operate at a constant tip speed ratio with varying wind speeds and enable the extraction of a part of the energy spilled by constant-speed constant-frequency systems. This paper describes the variable-speed constant-frequency wind-driven field modulated generator system under development at Oklahoma State University. Such systems appear to be most attractive in the "small" (10-50 kW) and "100 kW scale" (50-250 kW) sizes and for use in large capacity "multirotor on one tower" concepts.

**A79-18346** Wind power and other energy options. D. R. Inglis. Ann Arbor, Mich., University of Michigan Press, 1978. 308 p. 191 refs. \$16.

Past experience with wind power is considered along with the mechanics of wind energy conversion, small wind power installations, large wind power machines and installations, other solar-related energy sources, geophysical energy sources, nuclear power from fission, nuclear power from fusion, a comparison of dollar costs of wind power and nuclear power, social costs of wind power and nuclear power, and the choice of options. Attention is given to the power of the wind, early wind power development, windmills, home electric power and home heating, the visual acceptability of home windmills, the siting of large wind dynamos, offshore floating wind dynamos, home heating and cooling by using direct solar energy, large solar steam-electric systems, nuclear reactor development, advantages and disadvantages of nuclear power, the present status of nuclear power, the containment problem in nuclear fusion, the costs of large wind dynamos, transmission line costs, and the need for energy storage.

G.R.

## WIND, WAVES AND TIDES.

*Engineering*, vol. 218, no. 12, December 1978, p. 1318-1321.

Two symposia were organised by BHRA Fluid Engineering during August and September 1978. The first dealt with wave and tidal energy, the second with wind-energy systems. This article summarises some of the work reported at the symposia

## CALCULATION OF THE GEOMETRY AND PERFORMANCE OF A HIGH-SPEED WIND ROTOR.

Y. Mercadier.

Dept. of Mechanical Engineering, Faculty of Applied Sciences, University of Sherbrooke, Quebec, Canada.

*Wind Engineering*. 1978, Vol.2, 1, 25-36.

Wind rotor design has hitherto been based, particularly for lower powers, upon a compromise between high efficiency and simplicity of construction. Modern materials and fabrication techniques, however, permit the elimination of this compromise and the construction of rotors of maximum efficiency. The primary consideration in a wind power installation being the proportion of energy extracted from the wind rather than the actual power output, it becomes necessary to assess the performance of the turbine over its whole range of operating conditions. It is then possible to design a transmission system appropriate to the function of the installation and to specify operating limits. This sequence depends upon the accurate initial calculation of rotor geometry and performance.

**A79-10235 \*** DOE/NASA Mod OA wind turbine performance. T. R. Richards and H. E. Neustadter (NASA, Lewis Research Center, Cleveland, Ohio). In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings. Volume 3. (A79-10001 01-44) Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 2060-2063. 11 refs.

The NASA Lewis Research Center has designed, built, and is operating a 200-kW wind turbine (designated the Mod-OA-1) at Clayton, New Mexico. This paper compares the measured power-vs-speed performance of the Mod-OA-1 with predictions made using the PROP code. It is found that the actual performance closely matches predictions.

B.J.

**N78-26563\*** National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

### DOE/NASA MOD-OA WIND TURBINE PERFORMANCE

T. R. Richards and H. E. Neustadter 1978 8 p. refs. Proposed for presentation at the 13th Intersoc. Energy Conversion Eng. Conf., San Diego, Calif., 20-25 Aug. 1978.

(Contract E(49-26)-1004)

(NASA-TM-78916; E-9654; DOE/NASA/1004-78/13) Avail. NTIS HC A02/MF A01 CSCL 10A

Design and operation of a large wind turbine at Clayton, New Mexico is reported. This is the first of three identical 200 kW wind turbines to be operated on electric utility networks. A comparison between its predicted and measured power versus wind speed performance is presented.

G.G.



Energy Statistics for Large Wind Turbine Arrays  
by C.G. Justus & A.S. Mikhail

Wind Engineering, Vol. 2, No. 4, 1978, p. 184-202

Results of studies of large arrays of wind energy conversion systems (WECS) are summarized and synthesized into a methodology whereby array wind speed distributions and array power output distributions can be calculated for arrays of any number of sites and any spatial size. Required input for the method consists of: (1) array mean wind speed, (2) maximum distance between sites within an array, (3) number of sites in the array, and (4) standard deviation (or Weibull scale factor), either measured or inferred from reference statistical data. Sample results using this methodology are presented along with sensitivity analyses of the various input parameters. The sensitivity analysis results show that mean wind speed (including its seasonal and diurnal variation pattern, if important) is the most important factor in the array model. Sensitivity of the array model to other input parameters is about half as much as the mean wind speed sensitivity.

A78-49841 Improvement of windmill efficiency by boundary layer control. J. S. Montes (Tasmania, University, Hobart, Australia). Wind Engineering, vol. 2, no. 2, 1978, p. 103-114. 7 refs.

The desirability of using boundary layer suction to increase the efficiency of conventional windmills is discussed. The rotation of the windmill blades provides a source of internal flow which can be utilized as a simple pump for the boundary layer suction, and a simplified mathematical model of the internal flow is presented. Equations are integrated numerically for some assumed values of the windmill geometrical parameters, and it is shown that, if certain conditions are assumed, advantages of some 20% in the operational efficiency of a variable pitch windmill and 33% for the fixed-pitch windmill can be obtained. M.L.

CN-150,831, v.7 1978  
WIND ENERGY CONVERSION. VOLUME VII: EFFECTS  
OF TOWER MOTION ON THE DYNAMIC RESPONSE OF  
WINDMILL ROTOR. D.L. Sheu. Sept. 1978. 52p.

Massachusetts Inst. of Tech., ASRL-TR-184-13  
(Cambridge), Aeroelastic  
and Structures Research Lab.  
Contract E(11.1)-4131

Windmills  
Windmill blades

TJ Pierson, Richard E., 1934-  
810 Technician's and experimenter's  
.P53 guide to using sun, wind, and water  
power / Richard E. Pierson. West  
Nyack, N.Y. : Parker Pub. Co., 1973.  
270 p. : ill. ; 24 cm. \$9.95

4. Selecting a Wind System - 45

Why Wind is the First Priority (45) Two Basic Types of Wind Rotators  
(68) Wind Power Equations (68) Windmill Efficiencies (72) Windmill  
Comparisons (73) Practical Advantages and Disadvantages (75)

11. Building the Landing Propeller-Type Wind Power Plant - 175

Detailed Description (175) Propeller Instructions (177) The Prop Hub  
(189) Gear Box, Support Shaft and Collector Rings (192)

A78-24614 On the fluctuating power generation of large  
wind energy converters, with and without storage facilities. B.  
Sorensen (Copenhagen, University, Copenhagen, Denmark). Solar  
Energy, vol. 20, no. 4, 1978, p. 321-331. 19 refs.

Meteorological data for Denmark are used to analyze the power  
fluctuations and time duration patterns of large hypothetical wind  
energy generators. When the annual pattern of load variation is taken  
as the standard, it is found that the power fluctuations from wind  
energy generators are no greater than the fluctuations in the relation  
between power used and constant load. The addition of a  
hypothetical short-term storage capable of delivering the average  
power for 10-20 hr would make the wind energy system as  
dependable as one large nuclear power plant. The requirements for a  
long-term storage system that would permit full coverage by a wind  
energy system are discussed. M.L.

LIFTING FOILS TAP ENERGY OF FLOWING AIR OR  
WATER

Ben Kocivar  
Popular Science  
Vol. 212 no. 2 Feb. 1978  
p. 71-73, 168.

Wind model of lift translator looks like  
giant venetian blind with foils going up  
one side and down the other. As engi-  
neer Frank Pizzitola adjusts foils, Dr.  
Schneider (above) points to half of  
Volkswagen swing axle used to convert  
linear foil motion to rotary motion, which  
then drives electric generator.

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1978

# Institute of Electrical and Electronics Engineers, Region 6.

IEEE 1978 Region Six conference record  
Wind Generators and Energy Storage . . . . . 9

James N. Peterson  
Electrical Engineering Department, University of Idaho,  
Moscow, ID

Wind speed data over one year from six locations  
in the Pacific Northwest are analyzed to determine  
energy storage amounts sufficient to smooth the fluc-  
tuations in wind-generated electrical power. Hydro-  
power reservoirs are considered as the energy storage  
method and a definite relationship is determined be-  
tween the number of wind generators and amount of  
hydro storage. That relationship is

$$\text{no. of wind generators} = \frac{\text{ac-ft} \times \text{head}}{3.84 A_1}$$

where ac-ft is the amount of usable hydro reservoir,  
head is the effective head in ft, and  $A_1$  is the aver-  
age swept area of one windmill. This relationship,  
based on wind speed fluctuations, ensures adequate  
energy storage under the most adverse monthly condi-  
tions during the year analyzed. A wind generator net-  
work consisting of 880 wind generators, 1.8 megawatts  
each, distributed equally among five windmill farms  
and interconnected with existing hydroelectric stor-  
age would produce approximately 3.3 billion kilowatt-  
hours annually. The average annual plant capacity  
factor for such a network is 0.24.

## WIND POWER LIMITATIONS ASSOCIATED WITH VORTICES. J.L. LOTH. J. Energy, v.2, no.4, July-Aug.1978, p.216-222.

In the search for smaller and more powerful wind  
machines, the use of a vortex to create a region of low  
pressure and high velocity has been considered by several  
investigators. The theoretical maximum power coefficient of  
two vortex-ingesting wind turbine configurations have been  
computed. In addition, two wind turbine configurations  
which use the low pressure in the vortex core to exhaust into  
have also been analyzed.

## ON THE USE OF POWER LAWS FOR ESTIMATES OF WIND POWER POTENTIAL

Ernest W. Peterson and J.R. Hennessey, Jr.  
J. of Applied Meterology, vol. 17, no. 3, March 1978  
p. 390-394

The evaluation of wind power potential at a proposed aerogenerator site by extrapolation from measured  
winds at a reference level is investigated. It is shown that the total mean wind power density is not par-  
ticularly sensitive to the selection of roughness length or power law exponent; over the entire likely range  
of these parameters the wind power in the mean flow at typical aerogenerator hub heights is within 1.4-4  
times the power at a reference height of about 10 m. In lieu of *in situ* profile measurements, it is suggested  
that a power law exponent of 1/7 is adequate for realistic but conservative estimates of the available wind  
power except at extremely rough sites where the estimates may only be conservative.

N78-22488\* National Aeronautics and Space Administration.  
Marshall Space Flight Center, Huntsville, Ala.

### WIND WHEEL ELECTRIC POWER GENERATOR Patent Application

John W. Kaufman, inventor (to NASA) Filed 24 Feb. 1978  
16 p  
(NASA-Case-MFS-23515-1; US-Patent-Appi-SN-880726) Avail.  
NTIS HC A02/MF A01 CSCL 10A

An electric generator driven by the wind is described. Primary  
and auxiliary funnel-type, venturi ducts are mounted upon a  
housing for capturing wind currents and conducting the currents  
to a bladed wheel connected to generator apparatus. Additional  
air flows are also conducted onto the bladed wheel, rotating  
the wheel. The auxiliary ducts are disposed at an acute angle  
with respect to the longitudinal axis of the housing, and together  
with the rotatability of the housing and the ducts, permits capture  
of wind currents within a variable directional range. NASA

## TL National Aerospace and Electronics Conference

693 Dayton, Ohio, 1978.

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1978

3. Research in the Electrofluid Dynamic  
(EFD) Wind Driven Generator, John  
E. Minardi, M.O. Lawson, University of  
Dayton Research Institute. . . . . 869
4. A Low Cost Aerodynamic Heater  
Representing a Fully Matched Load for  
Wind Energy Systems, Maurice O.  
Lawson, University of Dayton Research  
Institute . . . . . 874

# OPTIMIZATION MODELS FOR THE ECONOMIC DESIGN OF WIND POWER SYSTEMS.

Hee Man Bae & Michael D. Devine

Solar Energy, Vol. 20, No. 6, 1978, p. 469-481,

Abstract—This paper presents optimization models for the economic design of large scale wind power systems. Two basic models are introduced: (1) Systems without storage—all power generated is fed directly into the existing network, and (2) systems with storage—the systems are operated as part of base load or peak load capacity. The objective of the models is to maximize the total net value of power generated under assumed operating rules and general conditions regarding wind speed and demand variations. The model for wind power systems without storage is developed to determine the total capacity of wind turbines that vary in the values of design parameters such as rotor diameter, tower height, and rated power. The model for systems with storage uses an analytical storage model as a basis of representing storage requirements. The model is designed for the case of little serial correlation in successively measured wind speeds. It is then modified for the case of a low degree of correlation. Separable programming is used as a solution technique in both models and limited computational results, based on available cost estimates and Oklahoma wind and demand data, are presented to illustrate the use of the models. In the first model, separable programming will yield a globally optimal solution for certain types of cost functions used. However, in the second model, the problem structure is such that a global optimum cannot be guaranteed.

TI 163.2 Greater Los Angeles Area Energy Symposium, Los Angeles, 1979.

.G74 Greater Los Angeles Area Energy Symposium  
1979 : Tuesday, May 23, 1978 ... Los Angeles,

- Wind Energy Generation with Hyperbolic Cooling Towers—Dr. Paul Rogers, California State University at Los Angeles

P.68

The method described in this article pertains to the secondary utilization of the exterior of hyperbolic cooling tower shells for supporting wind-rotors, and for producing electric energy directly and at a very reduced cost.

(Los Angeles

Council of Engineers Scientists  
proceedings ser. ; v. #)

NASA TM-78997

POWER TRAIN ANALYSIS FOR THE DOE/NASA 100-kw WIND TURBINE GENERATOR.

Robert C. Seidel, Harold Gold, and Leon M. Wenzel.  
National Aeronautics and Space Administration  
Lewis Research Center  
DOE/NASA/1028-78/19  
October 1978

# ECONOMIC DESIGN OF WIND ELECTRIC SYSTEMS.

Gary L. Johnson

IEEE Transactions on Power Apparatus and Systems, Vol. PAS-97, No. 2, March/April 1978, p. 554-562.

Long term wind records are used to select the rated wind speed for wind electric generators. The wind is characterized by a Weibull density function. Detailed results are presented for western Kansas. Graphs are presented which can be used to design a wind system for maximum specific output for a specified load factor at a given site. It is shown that a wind turbine rated at a wind speed of 9 m/s has a specific output within 80% of the maximum for a wide range of wind conditions.

ELECTRICAL POWER FROM SUN AND WIND IN MANITOBA, by J. S. C. McKee

Journal of Environmental Science and Health, Part A  
Environmental Science and Engineering, vol. A13, no. 8  
1978, p. 585-594

The potential usefulness of solar and wind energy as sources of electrical power is examined in the context of the projected needs of the province of Manitoba. It is suggested that as the capital costs of solar, wind and nuclear power plant construction are likely to become comparable within the next twenty years, a real choice exists for the consumer, because of purely regional factors.

N79-32711# Oak Ridge National Lab. Tenn.

## WIND TURBINES

John C. Yeoman, Jr. Dec. 1978 61 p refs

(Contract W-31-109-eng-38)

(ANL/CES/TE-78-9) Avail: NTIS HC A04/MF A01

Wind turbines, ranging in size from 200 W to 10 MW, are discussed as candidates for prime movers in community energy systems. Estimates of performance characteristics and cost as a function of rated capacity and rated wind speed are presented. Data concerning material requirements, environmental effects, and operating procedures also are given and are represented empirically to aid computer simulation.

DOE



**N78-31580/** Sandia Labs., Albuquerque, N. Mex.  
**PERFORMANCE EVALUATION OF WIND ENERGY CON-  
VERSION SYSTEMS USING THE METHOD OF BINS:  
CURRENT STATUS**

R. E. Akina Mar. 1978 21 p refs  
(Contract EY-76-C-04-0789)  
(SAND-77-1375) Avail. NTIS HC A02/MF A01

A detailed description of the method of bins, a technique of data collection and reduction for field performance evaluation of Wind Energy Conversion Systems (WECS) is provided. The method of bins is a straightforward yet useful approach to the complex problem of relating the response of a WECS to a variable wind field. Examples of typical results obtained using the method of bins are presented. Methods of determining that the measure of performance of a WECS obtained is correct are outlined. Areas in which further modifications to the technique may be appropriate are also discussed. ERA

**A79-15575** Operation and control of wind-electric systems. R. Ramakumar (Oklahoma State University, Stillwater, Okla.). In: Power system control and protection. New York, Academic Press, Inc., 1978, p. 261-290. 35 refs.

The paper examines the operational and control aspects of wind-electric systems referred to as intermittent base-load devices due to power generation by wind blowing alone. A brief review of significant past work, future trends and research needs is presented. Attention is given to operation fundamentals (constant vs. variable speed operation, basic components of a wind-electric conversion system), and to generation schemes classified according to output type and operation mode. Several combinations of speeds and outputs for wind energy utilization are proposed, depending on the end use of the electrical energy generated. Influential factors and necessary means to control output power for optimum performance are identified and discussed. SD

**N78-33594/** Department of Energy, Washington, D. C. Div.  
of Solar Technology  
**FEDERAL WIND ENERGY PROGRAM. PROGRAM  
SUMMARY**

Jan 1978 78 p  
(DOE/ET-0023/1) Avail. NTIS HC A05/MF A01

The objective of the Federal Wind Energy Program is to accelerate the development of reliable and economically viable wind energy systems and enable the earliest possible commercialization of wind power. To achieve this objective for small and large wind systems requires advancing the technology, developing a sound industrial technology base, and addressing the non-technological issues which could deter the use of wind energy. This summary report outlines the projects being supported by the program through FY 1977 toward the achievement of these goals. It also outlines the program's general organization and specific program elements. ERA

**N79-10647/** California Univ., Berkeley. Lawrence Berkeley  
Lab. Energy and Environment Div.  
**RELIABILITY OF WIND POWER FROM DISPERSED SITES:  
A PRELIMINARY ASSESSMENT**  
Edward Kahn Apr. 1978 46 p refs  
(Contract W-7405-eng-48)  
(LBL-6889) Avail. NTIS HC A03/MF A01

The reliability benefit of geographically dispersed wind turbine generators is analyzed. Electricity produced from wind machines experienced wide fluctuations of output at a given site. The conventional wisdom on wind power suggested that it is unrealistic to expect that wind generation will be sufficiently reliable to displace conventional capacity. DOE

**A79-43376** Program overview for the Wind Characteristics  
Program Element of the United States Federal Wind Energy Program.  
L. L. Wendell and C. E. Elderkin (Battelle Pacific Northwest  
Laboratory, Richmond, Wash.). In: Symposium on Turbulence,  
Dispersion, and Air Pollution, 4th, Reno, Nev., January 15-18, 1979,  
Preprints. (A79-43351 18-45) Boston, Mass., American Meteorologi-  
cal Society, 1978, p. 160-166. 17 refs.

The Wind Characteristics Program Element, a project undertaken to accelerate the development, commercialization and use of wind energy conversion systems by providing wind characteristics data needed to design and evaluate wind energy systems, is described. Attention is directed to four technical program areas: wind characteristics for design and program evaluation, mesoscale wind characteristics development of siting methodologies and wind characteristics relative to the day-to-day operation of wind energy conversion systems. The approaches adopted in each of these four program areas are discussed. C.K.D.

**AEROELASTIC WIND ENERGY CONVERTER**, by Goojarz  
Ahmadi.

Energy Conversion, vol. 18, no. 2, 1978, p. 115-120.

**Abstract**—The principle of aeroelastic wind energy conversion is introduced and an H-section model which works on the basis of torsional aeroelastic instability is described. A mathematical formulation for the prediction of the power coefficient of such wind machines is presented. A small model is constructed and tested in a wind tunnel. Although the efficiency of the model was very low, the system has the advantage of being capable of conversion of energy at very low wind speed. Furthermore, this wind energy converter is relatively simple and economical.

Energy conversion Wind energy Wind machine Aeroelastic machine

**N80-13674/** Midwest Research Inst., Golden, Colo. Solar  
Energy Research Inst.

**WIND ENERGY INNOVATIVE SYSTEMS Technical Status  
Report, Jul. 1978**

Irwin E. Vas Aug. 1978 58 p refs  
(Contract EG-77-C-01-4042)  
(SERI/PR-13-054) Avail. NTIS HC A04/MF A01

Economic and technical feasibility of innovative concepts and systems utilizing wind energy were investigated. Technical management of the 'wind energy innovative systems' program is discussed. The efforts of the current contracts are included within four major task areas: (1) theoretical thermodynamic and aerodynamic studies; (2) model design, fabrication, and test; (3) performance projections; and (4) economic evaluations. RES

**A79-34048** Optimal location of windmills. T. P. Torda. In:  
Alternative energy sources; Proceedings of the Miami International  
Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.  
(A79-34036 13-44) Washington, D.C., Hemisphere Publishing Corp.,  
1978, p. 1779-1785. 27 refs.

Technical and land use factors in the siting of electricity-generating windmills are considered. Methods for collecting wind data at a given location have traditionally included direct measurement, with the computation of the speed-up factor and the Frenkiel number to account for the influences of hills on the flow field. Attempts are being made to replace costly on-site measurements by wind tunnel modelling and numerical analysis of boundary layer flows. Laser velocimeters show promise as means of measuring velocity fields over full-scale terrain. Land use research is represented by reports and regulations issued by various government agencies. It is recommended that studies of the dependence of wind on the interaction of meteorological conditions with local topography and the necessary formulation of land use plans and regulations be carried out. A.L.W.

A79-41946 Off-shore based wind turbine systems /OS-WTS/ for Sweden - A systems concept study. R. Hardell (SIKOB AB, Sweden) and O. Ljungstrom (Flygtekniska Forsoksanstalten, Bromma, Sweden). (British Hydromechanics Research Association, International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, Oct. 3-5, 1978.) Wind Engineering, vol. 3, no. 1, 1979, p. 22-51. 12 refs.

Off-shore (OS) sites may prove to be more cost-effective and will reduce the land requirements for wind turbine systems (WTS) in Sweden. For sites located 10-20 km off shore, the median wind increases to 8.5 - 9.5 m/s (H=100 m) and the specific energy output (per turbine disc area) increases by 40%. Examples of design concepts of 7-14 MW unit capacity are given with associated cost estimates and with outlooks for the bigger second generation designs of 20-30 MW units. Environmental, social, and industrial aspects and impact of OS-WTS are discussed in comparison with land based systems. The OS-WTS advantages are: flexibility of site selection, good serviceability, and possibility to export to other countries by sea transport. Some disadvantages are: more severe environment at sea, higher costs for network attachment, and inspection difficulties in bad weather conditions. V.T.

CALCULATION OF WAKE EFFECTS IN WIND TURBINE PARKS,  
by P.J.H. Builtjes and J. Smit.  
Wind Engineering, vol. 2, no. 3, 1978, p.135-145.

*Considering the problem of the mutual spacing and pattern in which wind turbines have to be placed in order to get an optimal (from an aerodynamic and economical point of view) energy output on a restricted area, wake measurements have been carried out in a wind tunnel of a turning model of a Darrieus rotor. Using these wake results calculations considering interacting wakes of different turbines have been performed using the computer code "winds".*

*For small parks with up to 20 turbines an optimum energy output seems to be gained at a mutual distance of about 5 wing diameters; for larger parks above 60 turbines this value is about 9 diameters. In the case of larger parks a row pattern is preferable to a regular pattern.*

NASA TP-1359 Windmills

ENGINEERING HANDBOOK ON THE ATMOSPHERIC ENVIRONMENTAL GUIDELINES FOR USE IN WIND TURBINE GENERATOR DEVELOPMENT. Walter Frost, B.H. Long, Tenn. Univ. Space Inst. and R.E. Turner. MSFC. Dec.1978. 372p.

PERFORMANCE PREDICTION METHODS FOR HORIZONTAL AXIS WIND TURBINES, by D. J. Milborrow.  
Wind Engineering, vol. 2, no. 3, 1978, p. 165-175.

*A method of assessing the performance characteristics of horizontal axis wind turbines has been developed, using the aerofoil theory which is applied to axial flow fans. The capabilities of the method are compared with those of the propeller theory normally used for windmill performance assessment. Weaknesses in the propeller theory are identified and it is concluded that the fan analysis technique has certain advantages and lends itself to further refinement.*

*Both theories have been applied to a particular windmill design for which field measurements are available (the LT Co. aerogenerator at Aldborough). Fan theory predicts rather higher peak performance in agreement with LT Co. observations that design performance has been exceeded.*

N79-29883 Wisconsin Univ. - Madison.  
AN ASSESSMENT OF WIND CHARACTERISTICS AND WIND ENERGY SYSTEMS APPLICATIONS TO ELECTRIC UTILITIES IN WISCONSIN AND SECTIONS OF MINNESOTA, IOWA AND ILLINOIS Ph.D. Thesis  
Carel Christiaan Dewinkel 1978 313 p  
Avail. Univ. Microfilms Order No. 7902397

Wind speed data from the National Climatic Center were analyzed to assess the wind characteristics for the application of wind energy conversion systems (WECS) to electric utility. In addition, five Coast Guard Stations along the shores of Lakes Superior and Michigan were analyzed. WECS as part of an electric utility system can be evaluated by electric utility planning methods. The method of analysis employs predicted wind power output data, based on 5 years of wind speed observations, that are subtracted on an hourly basis from the predicted load levels. These adjusted hourly load levels serve as an input of a conventional production cost model. Savings in production costs over the lifetime of the WECS, minus the O & M, taxes and insurance costs of the WECS, result in the estimated break even capital cost of the WECS. Dissert. Abstr.

POWER FROM THE OCEAN WINDS, by David Rittenhouse Inglis  
Environment, vol. 20, no. 8, October 1978, p. 17-20

An increased emphasis on windpower could add significantly to our energy resources. Because winds are normally stronger at sea than on land, tapping the sea winds could be especially profitable—but no one will try.

TK  
7800  
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1978  
Institute of Electrical and Electronics  
Engineers. Region 5.  
Energy 78 : 1978 Region Five annual  
conference. April 16-18, 1978. Tulsa.  
On the Use of Eddy-Current Couplings in Wind-Driven Synchronous Machines

A. Q. Qazi, NED University of Engineering and Technology, Karachi,  
Pakistan, R. Ramakumar, Oklahoma State University

Controlling a Wind Generator for Increased Efficiency  
M. E. Valdez, E. R. Kittlaus, California State University, Long Beach

Efficient Use of Wind Energy by Using Static Slip Recovery Schemes -  
A Simulator Study - V. Rajagopalan, Univ. de Quebec, Trois Rivières  
Canada & K. S. Rao, M. N. S. Swamy, Concordia University, Canada

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1541  
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1978  
Inglis, David Rittenhouse, 1905-  
Wind power and other energy options /  
David Rittenhouse Inglis. -- Ann Arbor :  
University of Michigan Press, c1978.  
x, 298 p. : ill. ; 23 cm.  
Bibliography: p. 281-293.  
Includes index.  
ISBN 0-472-09303-7  
1. Wind power. 2. Atomic power-plants.  
3. Power resources. I. Title.

A79-31916 # Design and application of large wind turbine  
generators. D. F. Warne (Electrical Research Association, Ltd.,  
Leatherhead, Surrey, England). In: Energy and aerospace; Proceed-  
ings of the Anglo-American Conference, London, England,  
December 5-7, 1978. (A79-31908 12-44) London, Royal Aeronauti-  
cal Society, 1979. 15 p. 12 refs.

An outline is provided of several national programs which are  
concerned with the construction of new machines for the utilization  
of wind energy. General factors governing economics are examined,  
taking into account the importance of wind speed, the importance of  
scale, and the rate of machine output. Design choices in large wind  
turbine generators are also discussed, giving attention to design  
decisions related to turbine type, the turbine diameter, aspects of  
pitch control, the number of blades, the choice of fixed or variable  
turbine speed, the significance of upwind or downwind location as a  
design option, and the general question of system stiffness. G.R.

N80-10623# California Univ., Livermore. Lawrence Livermore  
Lab.  
METHODS OF ESTIMATING THE RELIABILITY OF WIND  
ENERGY SYSTEMS WITH STORAGE  
C. R. Glassey and G. F. Moyer 1978 61 p refs  
(Contract W-7405-eng-48)  
(UCRL-15005) Avail: NTIS HC A05/MF A01

Some preliminary results obtained in analyzing the reliability  
of wind generator storage systems are presented. The investigation  
took two separate approaches: simulation and probabilistic  
modeling, to reveal the trade-offs which can be made between  
generating capacity and storage capacity to attain a desired level  
of reliability. The performance criterion used throughout this work  
was the frequency of occurrence of empty storage. This criterion  
was essentially the same as the frequency of loss of load. DOE

A79-31455 A hybrid wind turbine suitable for developing  
regions. E. Bilgen, I. Paraschivoiu, and M. Kaine (Ecole Polytech-  
nique, Montreal, Canada). In: Renewable alternatives; Proceedings of  
the Fourth Annual Conference, London, Ontario, Canada, August  
20-24, 1978. Volume 2. (A79-31401 12-44) Winnipeg, Solar Energy  
Society of Canada, Inc., 1978. 6 p. 5 refs.

In this article, a study is presented on a hybrid wind turbine  
which consists of two vertical axis coaxial turbines, one of Savonius  
type and the other a screw type. The Savonius type turbine rotates in  
a uniform velocity field while the second, the screw type converts  
the kinetic energy of the vortex flow generated in the center of the  
first turbine. Theoretically, it is shown earlier that the total  
efficiency of such a hybrid wind turbine can have a higher efficiency  
compared to that obtained from a simple system and the simplicity  
of the Savonius for manufacturing and maintenance of the system is  
retained. A model has been built to study the overall performance of  
this system, the results of which will serve to design and build a  
prototype hybrid turbine for the Northern regions of Quebec.  
(Author)

A79-16743 Controlling a wind generator for increased  
efficiency. M. E. Valdez and E. R. Kittlaus (California State Univer-  
sity, Long Beach, Calif.). In: Energy '78; Annual Conference, Tulsa,  
Okla., April 16-18, 1978, Record of Conference Papers. (A79-  
16726 04-44) New York, Institute of Electrical and Electronics  
Engineers, Inc., 1978, p. 247-249.

Two procedures for controlling a wind generator-storage battery  
system to obtain increased efficiency are presented - one optimal and  
the other practical. It is shown that an existing generator and blade  
designed as a battery charger can be used for supplying a much larger  
load. By simply fixing the field current to a value given by the  
average wind conditions and increasing the size of the storage  
batteries, more energy can be obtained. This concept is applicable to  
small and medium-size installations. B.J.



**A79-10236** On-line control of a large horizontal axis wind energy conversion system and its performance in a turbulent wind environment. J. M. Kos (United Technologies Corp., Hamilton Standard Div., Windsor Locks, Conn.). In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings. Volume 3. (A79-10001 01-44) Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 2064-2073.

This paper describes a closed loop, shaft torque control for controlling the power of a large (2 megawatt), variable pitch, horizontal axis wind turbine, driving a synchronous generator connected to a large power system (on-line operation). A control mode is presented which provides a stable, responsive control system by sensing shaft torque and rotor rotational speed. Dynamic performance results from a digital simulation of the system operating on-line in a turbulent wind environment are presented. The results show the dramatic improvement in on-line system performance that can be achieved with the responsive shaft torque control described in this paper. The responsive control significantly attenuates both blade loads and electrical power fluctuations due to wind turbulence and will go far toward maximizing the on-line operating hours of the wind energy conversion system. (Author)

**A79-16742** On the use of eddy-current couplings in wind-driven synchronous machines. A. Q. Qazi (Pakistan University of Engineering and Technology, Karachi, Pakistan) and R. Ramakumar (Oklahoma State University, Stillwater, Okla.). In: Energy '78; Annual Conference, Tulsa, Okla., April 16-18, 1978, Record of Conference Papers. (A79-16726 04-44) New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 242-246. 12 refs.

This paper discusses the suitability of eddy-current couplings in the mechanical interfaces of wind-driven synchronous machines. Based on the computer simulation results presented under gusting wind conditions, recommendations are made for choosing the coupling design parameters for satisfactory operation. Eddy-current couplings turn out a very good performance even under severe gusting and highly variable wind regimes and therefore are strongly recommended for application in wind-electric conversion systems. (Author)

**A79-21302 \* #** Microprocessor control of a wind turbine generator. A. J. Gnecco and G. T. Whitehead (NASA, Lewis Research Center, Cleveland, Ohio). *Institute of Electrical and Electronics Engineers, Conference on Industrial Applications of Microprocessors, Philadelphia, Pa., Mar. 20-22, 1978, Paper. 15 p.* Contract No. E(49-26)-1028.

This paper describes a microprocessor based system used to control the unattended operation of a wind turbine generator. The turbine and its microcomputer system are fully described with special emphasis on the wide variety of tasks performed by the microprocessor for the safe and efficient operation of the turbine. The flexibility, cost and reliability of the microprocessor were major factors in its selection. (Author)

**A79-16744** Efficient use of wind energy by using static slip recovery systems - A simulator study. V. Rajagopalan (Québec, Université, Trois-Rivières, Canada), K. S. Rao, and M. N. S. Swamy (Concordia University, Montreal, Canada). In: Energy '78; Annual Conference, Tulsa, Okla., April 16-18, 1978, Record of Conference Papers. (A79-16726 04-44) New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 250-254. 6 refs.

Consideration is given to the computer simulation of an efficient wind energy scheme utilizing a slip energy recovery system. A new simulator WESS (Wind Energy System Simulator) is very useful in designing the static power converter system by repeated analysis. This simulator is particularly effective in making an optimum choice of  $dI/dt$  limiting reactor and  $dV/dt$  limiting snubber components, resulting in considerable reduction in high frequency line current harmonics. Experimental results obtained on a 2-kW scheme are compared with results obtained from a simulator run. B.J.

**A79-13871 #** Optimum selection of a wind turbine generator system. J. K. Shultz, L. A. Poch, and N. D. Eckhoff (Kansas State University of Agriculture and Applied Science, Manhattan, Kan.). *American Institute of Aeronautics and Astronautics and Arizona Solar Energy Research Commission, Conference on Solar Energy: Technology Status, Phoenix, Ariz., Nov. 27-29, 1978, AIAA Paper 78-1774. 8 p.* 11 refs.

A method is described for the selection of the optimum size (i.e., rated power and speed) for a wind turbine generating system (WTGS) such that, for given wind speed conditions and for given demand power requirements, the annual economic savings are maximized by using the WTGS compared to purchasing all power from a utility. No storage of excess generated electricity is considered and any demand in excess of that generated by the WTGS is assumed to be supplied by the utility grid. The economic saving realized with the optimum sized WTGS is examined for various problem variables such as the degree of variability in the wind speed and in the demand load throughout the day and from season to season. (Author)

**N78-23558\* #** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. **WAKE CHARACTERISTICS OF A TOWER FOR THE DOE-NASA MOD-1 WIND TURBINE** Joseph M. Savino, Lee H. Wagner, and Mary Nash. Apr. 1978. 76 p. refs. (Contract E(49-26)-1028) (NASA-TM-78853; E-9575; DOE/NASA/1028-78/17) Avail. NTIS HC A05/MF A01 CSCI 10A

A 1/40th scale model of a tower concept designed for a MOD-1 wind power turbine was tested in a low speed wind tunnel. Wake wind speed profiles were measured, and from these were determined local values of wake minimum velocity ratio, average velocity ratio, and width over a range of tower elevations and wind approach angles. Comparison with results from two other all tubular models (MOD-0 and eight leg designs) tested earlier in the same tunnel indicated that wake width and flow blockage at the rotor plane of rotation were slightly larger for the MOD-1 tower than for the other two models. The differences in wake characteristics were attributed to differences in tower geometry and member dimensions. Author

**A79-10240** Toroidal Accelerator Rotor Platforms for wind energy conversion. A. L. Weisbrich (Kaman Aerospace Corp., Bloomfield, Conn.). In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings. Volume 3. (A79-10001 01-44) Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 2099-2107. 10 refs.

Presented is a Toroidal Accelerator Rotor Platform (TARP) design for Wind Energy Conversion Systems (WECS) application. A TARP WECS is analyzed for performance and economic viability using both experimental results and analytical approaches. Results indicate a TARP WECS to have unusual promise and potential for meeting the diverse prerequisites for a WECS to become a viable energy system alternative. These are reduced energy cost, applicability and interface adaptability to a broad range of uses, environments and structures, as well as aesthetic design with minimal environmental impact. One of TARP's principal design features include adaptation of its support structure for multi-purpose use to conventional base structures which greatly aids its economic viability. (Author)

**N78-26542\* #** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. **TRANSIENT RESPONSE TO THREE-PHASE FAULTS ON A WIND TURBINE GENERATOR** Ph.D. Thesis - Toledo Univ. Leonard J. Gilbert. Jun. 1978. 146 p. refs. (NASA-TM-78902; E-9638) Avail. NTIS HC A07/MF A01 CSCI 10A

In order to obtain a measure of its responses to short circuits a large horizontal axis wind turbine generator was modeled and its performance was simulated on a digital computer. Simulation of short circuit faults on the synchronous alternator of a wind turbine generator, without resort to the classical assumptions generally made for that analysis, indicates that maximum clearing times for the system tied to an infinite bus are longer than the typical clearing times for equivalent capacity conventional machines. Also, maximum clearing times are independent of tower shadow and wind shear. Variation of circuit conditions produce the modifications in the transient response predicted by analysis. P.R.A.

CALCULATION OF WAKE EFFECTS IN WIND TURBINE PARKS,  
by P.J.H. Builtjes and J. Smit.  
Wind Engineering, vol. 2, no. 3, 1978, p.135-145.

*Considering the problem of the mutual spacing and pattern in which wind turbines have to be placed in order to get an optimal (from an aerodynamic and economical point of view) energy output on a restricted area, wake measurements have been carried out in a wind tunnel of a turning model of a Darrieus rotor. Using these wake results calculations considering interacting wakes of different turbines have been performed using the computer code "winds".*

*For small parks with up to 20 turbines an optimum energy output seems to be gained at a mutual distance of about 5 wing diameters; for larger parks above 60 turbines this value is about 9 diameters. In the case of larger parks a row pattern is preferable to a regular pattern.*

Wind Power and Electric Utilities: A Review of the  
Problems and Prospects. by H. Davitian

Wind Engineering, Vol. 2, No. 4, 1978, p. 234-255

*The upper limit on the practically exploitable energy annually available from wind power in the United States is roughly  $1.2 \times 10^{12}$  kWh per year. Electric utilities comprise the largest potential market for wind machines in the megawatt power range. The use of windpower poses a variety of problems for utilities primarily due to the uncontrollability of the power source and the high degree of variability of the wind. Differences in the dynamic behaviour of the wind and of utility load patterns and the problems that arise from these differences are described in this paper. Utility capacity expansion methods and modifications to them to incorporate the characteristics of wind machines into the analytic procedure are outlined and results from initial studies employing these modifications are reviewed. These results indicate that, in general, storage devices are too expensive to be purchased by utilities if they serve mainly to balance the output of the wind machines; that wind machines tend to supplant purchases of conventional baseload capacity but require additional peaking units; and that the economic value of wind machines to utilities is composed of savings in both fuel- and capacity-related expenditures for conventional equipment. Estimates of the value of wind machines to utilities are in the \$500-700 per kilowatt range in favorable regions of the U.S. Engineering design studies suggest that the cost of producing and installing wind machines might be brought down to this level with mass production and anticipated advances in design and production processes. Given the availability of high winds, the most favorable locations for the early use of wind generators are in isolated areas currently relying on small, petroleum fueled generating units and in regions with large hydropower authorities, since such systems contain immense reservoirs of stored energy which could provide an ideal complement to wind generation.*

SYNCHRONIZATION OF WIND TURBINE GENERATORS  
AGAINST AN INFINITE BUS UNDER GUSTING WIND  
CONDITIONS.

H. H. Hwang & Leonard J. Gilbert  
IEEE Transactions on Power Apparatus and  
Systems, Vol. PAS-97, No. 2, March/April  
1978, p. 536-544.

*Studies of synchronizing a wind turbine generator against an infinite bus are performed on a digital computer. In the digital simulation, wind gusts of different magnitudes and durations are hypothesized. Prior to the synchronization, differences of the frequency and phase position between voltages of the alternator and the bus are also included in the simulation. Solutions for rotor speed, generator power angle, electromagnetic torque, wind turbine torque, wind turbine blade pitch angle, and armature current are simulated and presented graphically. The ERDA-NASA 100-kw wind turbine is used as a case study. The results so obtained will thus have immediate applications.*

NASA CP-2034

WIND TURBINE STRUCTURAL DYNAMICS. Dean R. Miller,  
LeRC, ed. (Workshop sponsored by DOE and held  
LeRC, Nov. 15-17, 1977). Mar. 1978. 290p.

(CONF-771148—, pp 109-116) Summary of static load  
test of the MOD-0 blade. Miller, D.R. (Lewis Research Center, 1143  
Cleveland). 1978.

From Wind turbine structural dynamics conference; Cleve-  
land, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

A static load test was performed on the spare Mod-0 windtur-  
bine blade to define load transfer at the root end of the blade, and to  
validate stress analysis of this particular type of blade construction  
(frame and stringer). Analysis of the load transfer from the airfoil  
skin to the shank tube predicted a step change in spanwise stress in  
the airfoil skin at station 81.5 inches (STA 81.5). For flatwise  
bending a 40% reduction in spanwise stress was predicted, and for  
edgewise bending a 6% reduction. Experimental results verified the  
40% reduction for flatwise bending, but indicated about a 30%  
reduction for edgewise bending.



## NASA CP-2034

**WIND TURBINE STRUCTURAL DYNAMICS.** Dean R. Miller  
LeRC, ed. (Workshop sponsored by DOE and held  
LeRC, Nov. 15-17, 1977). Mar. 1978. 290p.

(CONF-771148—, pp 117-150) DOE/NASA MOD-0 100  
kW wind turbine: test results. Glasgow, J.C. (Lewis Research Center,  
Cleveland). 1978.

From Wind turbine structural dynamics conference; Cleve-  
land, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

The Mod-0 100kW Wind Turbine was designed and fabricat-  
ed by the NASA under the direction of the U.S. Department of  
Energy to assess technology requirements and engineering problems  
of large wind turbines. Data which is associated with rotor and  
machine dynamics problems encountered and the machine modifica-  
tions incorporated as a solution are presented. These include high  
blade loads due to tower shadow, excessive nacelle yawing motion,  
and power oscillations. The results of efforts to correlate measured  
wind velocity with power output and wind turbine loads are also  
discussed.

## NASA CP-2034

**WIND TURBINE STRUCTURAL DYNAMICS.** Dean R. Miller  
LeRC, ed. (Workshop sponsored by DOE and held  
LeRC, Nov. 15-17, 1977). Mar. 1978. 290p.

(CONF-771148—, pp 151-156) Power oscillation of the  
MOD-0 wind turbine. Seidel, R.C. (Lewis Research Center, Cleve-  
land). 1978.

From Wind turbine structural dynamics conference; Cleve-  
land, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

The Mod-0 power has noise components with varying fre-  
quency patterns. Magnitudes reach more than forty percent power at  
the frequency of twice per rotor revolution. Analysis of a simple  
torsional model of the power train predicts less than half the ob-  
served magnitude and does not explain the shifting frequencies of the  
noise patterns.

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National SMTE Symposium and Exhibition, 23rd,  
Anaheim, Calif., 1978.

Selective application of materials for  
products and energy ... c1978.

Includes bibliographical references and  
index.

1. Materials—Congresses. I. Society  
for the Advancement of Material and Process

AN OPERATING 200 KW HORIZONTAL AXIS WIND TURBINE

457

Charles L. Hunnicutt, Bradford Linscott and Robert A.  
Wolf

(DOE/NASA/3132-78/1) Employing static excitation  
control and tie line reactance to stabilize wind turbine generators.  
Hwang, H.H.; Mozeico, H.V.; Guo, T. (Hawaii Univ., Honolulu  
(USA)). Apr 1978. Contract EX-76-A-29-1004. 78p. (NASA-CR—  
135344). Dep. NTIS, PC A05/MF A01.

This study presents an analytical representation of a wind  
turbine generator which employs blade pitch angle feedback control.  
A mathematical model is formulated. With the functioning MOD-0  
wind turbine serving as a practical case study, results of computer  
simulations of the model as applied to the problem of dynamic  
stability at rated load are presented. The effect of the tower shadow  
is included in the input to the system. Different configurations of the  
drive train, and optimal values of the tie line reactance are used in  
the simulations. Computer results reveal that a static excitation  
control system coupled with optimal values of the tie line reactance  
will effectively reduce oscillations of the power output, without the  
use of a slip clutch.

### DOE/NASA Mod-0A Wind Turbine Performance.

T. R. Richards, and H. E. Neustadter.

National Aeronautics and Space Administration,  
Cleveland, OH. Lewis Research Center. 1978. 9p CONF-  
780801-23, NASA-TM-78916

DOE/NASA/1004-78/13 Price code: PC A02/MF A01

As part of the national wind energy program under the  
direction of the Department of Energy, the NASA-Lewis  
Research Center has designed and built, and is now  
operating, a large wind turbine at Clayton, New Mexico.  
Designated the Mod-0A-1, this is the first of three identical  
200 kW wind turbines to be operated on electric utility net-  
works. This machine was installed at Clayton, New Mexico,  
in November 1977. A comparison between its predicted  
and measured power versus wind speed performance is  
presented. (ERA citation 03:056868)

TA National SMTE Symposium and Exhibition, 23rd,  
418.9 Anaheim, Calif., 1978.

.C6 Selective application of materials for  
A3 products and energy ... cl978.

1978 (Card 2)

Includes bibliographical references and  
index.

1. Materials--Congresses. I. Society  
for the Advancement of Material and Process

WIND TURBINE GENERATOR APPLICATION PLACES UNIQUE DEMANDS 409  
ON TOWER DESIGN AND MATERIALS (Mod 1)

James P. Kita

TA National SMTE Symposium and Exhibition, 23rd,  
418.9 Anaheim, Calif., 1978.

.C6 Selective application of materials for  
A3 products and energy ... cl978.

1978 (Card 2)

Includes bibliographical references and  
index.

1. Materials--Congresses. I. Society  
for the Advancement of Material and Process

FATIGUE IMPACT ON MOD-1 WIND TURBINE DESIGN 417

Clyde V. Stahle, Jr.

## NASA CP-2034

**WIND TURBINE STRUCTURAL DYNAMICS.** Dean R. Miller,  
LeRC, ed. (Workshop sponsored by DOE and held  
LeRC, Nov.15-17,1977). Mar.1978. 290p.

(CONF-771148—, pp 219-225) Fatigue load spectra for  
upwind and downwind rotors. Andrews, J.S. (Boeing Engineering and  
Construction, Seattle) 1978.

From Wind turbine structural dynamics conference; Cleve-  
land, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

Effect of both alternating and mean load on the fatigue life of  
an upwind and downwind MOD-2 wind turbine system is presented.  
It was shown that the fatigue damage varies as the product of the  
stress range cubed and the maximum stress. Hence, the alternating  
flapwise load caused by tower shadow and wind gradient is an  
important factor in determining rotor blade life.

## NASA CP-2034

**WIND TURBINE STRUCTURAL DYNAMICS.** Dean R. Miller,  
LeRC, ed. (Workshop sponsored by DOE and held  
LeRC, Nov.15-17,1977). Mar.1978. 290p.

(CONF-771148—, pp 167-178) MOD-1 wind turbine gen-  
erator analysis. Barton, R.S. (General Electric Co., Philadelphia).  
1978.

From Wind turbine structural dynamics conference; Cleve-  
land, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

A general summary of the MOD-1 Wind Turbine Generator  
control system and simulation is presented. Mechanical and speed  
stabilization control means to add drive train damping are mentioned  
and MOD-1 simulation results showing the effects of speed stabiliza-  
tion are displayed.

A79-20829 \* An operating 200 kW horizontal axis wind  
turbine. C. L. Hunnicutt (Lockheed Aircraft Service Co., Ontario,  
Calif.), B. Linscott, and R. A. Wolf (NASA, Lewis Research Center,  
Cleveland, Ohio). In: Selective application of materials for products  
and energy; Proceedings of the Twenty-third National Symposium  
and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23)  
Azusa, Calif., Society for the Advancement of Material and Process  
Engineering, 1978, p. 457-478.

Output from the 200-kilowatt machine will be enough to meet  
the power requirements of about 60 families. The experimental wind  
turbine generator (WTG) is a two-bladed, horizontal-axis, rotor  
system driving a synchronous electric generator through a step-up  
gear box located within a nacelle. The nacelle is mounted on top of a  
100-foot tower with the rotor located downwind from the tower.  
The 200-kilowatt rated power output of the wind turbine is achieved  
at a turbine rotor speed of 40 rpm and a rated wind speed of 18.3  
mph. The rated wind speed is defined as the lowest wind speed at  
which full power is achieved. Attention is given to operational  
details, aspects of blade design, blade fabrication, the use of strain  
gages, questions of aeroelastic stability, and an early analysis of test  
data. G.R.

TA National SMTE Symposium and Exhibition, 23rd,  
 418.9 Anaheim, Calif., 1978.  
 .C6 Selective application of materials for  
 A3 products and energy ... cl978.  
 1978 (Card 2)

Includes bibliographical references and  
 index.

1. Materials—Congresses. I. Society  
 for the Advancement of Material and Process

BACKGROUND AND SYSTEM DESCRIPTION OF THE MOD 1 WIND TURBINE 403  
 GENERATOR

E. H. Ernst

**N78-23556\*** National Aeronautics and Space Administration,  
 Lewis Research Center, Cleveland, Ohio.

**COMPARISON OF COMPUTER CODES FOR CALCULATING  
 DYNAMIC LOADS IN WIND TURBINES**

David A. Spera 1977 39 p. refs. Presented at the 3d Bion.  
 Conf. and Workshop on Wind Energy Conversion Systems,  
 Washington, D. C., 19-21 Sep. 1977

(Contract E(49-26)-1028)

(NASA-TM-73773; DOE/NASA/1028-78/16; E-9577) Avail:  
 NTIS HC A03/MF A01 CSCL 10B

Seven computer codes for analyzing performance and loads  
 in large, horizontal axis wind turbines were used to calculate  
 blade bending moment loads for two operational conditions of  
 the 100 kW Mod-0 wind turbine. Results were compared with  
 test data on the basis of cyclic loads, peak loads, and harmonic  
 contents. Four of the seven codes include rotor-tower interaction  
 and three were limited to rotor analysis. With a few exceptions,  
 all calculated loads were within 25 percent of nominal test  
 data.

Author

**N77-30811\*** National Aeronautics and Space Administration,  
 Lewis Research Center, Cleveland, Ohio.

**DRIVE TRAIN NORMAL MODES ANALYSIS FOR THE  
 ERDA/NASA 100-KILOWATT WIND TURBINE GENERA-  
 TOR**

T. L. Sullivan, D. R. Miller, and D. A. Spera Jul. 1977 34 p  
 refs

(Contract E(49-26)-1028)

(NASA-TM-73718; E-9266; ERDA/NASA-1028-77/1) Avail:  
 NTIS HC A03/MF A01 CSCL 10B

Natural frequencies, as a function of power were determined  
 using a finite element model. Operating conditions investigated  
 were operation with a resistive electrical load and operation  
 synchronized to an electrical utility grid. The influence of certain  
 drive train components on frequencies and mode shapes is shown.  
 An approximate method for obtaining drive train natural  
 frequencies is presented.

Author

**A77-48898\*** Experimental data and theoretical analysis of  
 an operating 100 kW wind turbine. B. S. Linscott, J. Glasgow  
 (NASA, Lewis Research Center, Cleveland, Ohio), W. D. Anderson,  
 and R. E. Donham (Lockheed California Co., Burbank, Calif.). In:  
 Intersociety Energy Conversion Engineering Conference, 12th, Wash-  
 ington, D.C., August 28-September 2, 1977, Proceedings, Volume 2.  
 (A77-48701 23-44) La Grange Park, Ill., American Nuclear Society,  
 Inc., 1977, p. 1633-1650. 8 refs. Contract No. NAS3-20036.

Part of the cooperative effort between NASA and ERDA has  
 been the design and the erection of an experimental wind turbine by  
 the NASA-Lewis Research Center. This 100 kW turbine, designated  
 the Mod-0, is located at the NASA Plum Brook site near Sandusky,  
 Ohio. Experimental test data have been correlated with analyses of  
 turbine loads and complete system behavior of the 100 kW Mod-0  
 wind turbine generator over a broad range of steady state conditions,  
 as well as during transient conditions. The deficit in the ambient  
 wind field due to the upwind tower turbine support structure was  
 found to be very significant in exciting higher harmonic loads  
 associated with the flapping response of the blade in bending.

(Author)

**ERDA/NASA 100-Kilowatt MOD-0 Wind Turbine  
 Operations and Performance.**

R. L. Thomas, and T. R. Richards.

National Aeronautics and Space Administration,  
 Cleveland, Ohio. Lewis Research Center. Sep 77, 19p  
 NASA-TM-73825, CONF-770921-6

ERDA/NASA/1028-77/9 Price code: PC A02/MF A01

The ERDA/NASA 100 kW Mod-0 wind turbine became  
 operational in September 1975 at the NASA Plum Brook  
 Station near Sandusky, Ohio. The operation of the wind  
 turbine has been fully demonstrated and includes start-up,  
 synchronization to the utility network, blade pitch control  
 for control of power and speed, and shut-down. Also, fully  
 automatic operation has been demonstrated by use of a  
 remote control panel, 50 miles from the site, similar to  
 what a utility dispatcher might use. This report briefly  
 describes the operation systems and experience with the  
 wind turbine loads, electrical power and aerodynamic per-  
 formance obtained from testing. (ERA citation 03:017384)



**Synchronization of the DOE/NASA 100-Kilowatt Wind Turbine Generator with a Large Utility Network.**

L. J. Gilbert.

National Aeronautics and Space Administration,  
Cleveland, Ohio. Lewis Research Center. Dec 77. 19p  
NASA-TM-73861

DOE/NASA/1028-77/10 Price code: PC A02/MF A01

The DOE/NASA 100 kilowatt wind turbine generator system has been routinely successfully synchronized with a large utility network since September 1976. The system equipments and procedures associated with the synchronization process are described. Time-history traces of typical synchronizations are presented indicating that power and current transients resulting from the synchronizing procedure are limited to acceptable magnitudes. (ERA citation 03:023589)

(N-77-19580) **Synchronization of the ERDA-NASA 100 kW wind turbine generator with large utility networks.** Hwang, H.H.; Gilbert, L.J. (National Aeronautics and Space Administration, Cleveland, Ohio (USA). Lewis Research Center). Jul 1977. 17p. (NASA-TM-X-73613; E-9096). NTIS PC A02/MF A01.

The synchronizing of a wind turbine generator against an infinite bus under random conditions is studied. With a digital computer, complete solutions for rotor speed, generator power angle, electromagnetic torque, wind turbine torque, wind turbine blade pitch angle, and armature current are obtained and presented by graphs.

**N77-30699\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**DYNAMIC BLADE LOADING IN THE ERDA/NASA 100 kW AND 200 kW WIND TURBINES**

D. A. Spera, D. C. Janetzke, and T. R. Richards Aug. 1977 16 p refs Presented at the Natl. Conf. of the Am. Wind Energy Assoc., Boulder, Colo., 11-14 May 1977

(Contract E(49-26)-1004)

(NASA-TM-73711; ERDA/NASA-1004-77/2; E-9242) Avail: NTIS HC A02/MF A01 CSCL 10A

Dynamic blade loads, including aerodynamic, gravitational, and inertial effects, are presented for two large horizontal-axis wind turbines: the ERDA-NASA 100 kW Mod-0 and 200 kW Mod-0A wind power systems. Calculated and measured loads are compared for an experimental Mod-0 machine in operation. Predicted blade loads are also given for the higher power Mod-0A wind turbine now being assembled for operation as part of a municipal power plant. Two major structural modifications have been made to the Mod-0 wind turbine for the purpose of reducing blade loads. A stairway within the truss tower was removed to reduce the impulsive aerodynamic loading caused by the tower wake on the downwind rotor blades. Also, the torsional stiffness of the yaw drive mechanism connecting the turbine nacelle to the tower was doubled to reduce rotor-tower interaction loads. Measured reductions in load obtained by means of these two modifications equaled or exceeded predictions. Author

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**A78-40367 Madaras Rotor Power Plant.** D. H. Whitford, J. E. Minardi, F. L. Starnes, and B. S. West (Dayton, University, Dayton, Ohio). In: *Recent advances in engineering science; Proceedings of the Fourteenth Annual Meeting*, Bethlehem, Pa., November 14-16, 1977. (A78-40301 17-31) Bethlehem, Pa., Lehigh University, 1977, p. 1281-1290. Contract No. E(49-18)-2273.

The Madaras Rotor Power Plant project, investigated in the 1930 to 1934 time period, used 90-ft high by 22.2-ft diameter rotating, vertically-mounted cylinders to convert wind power to Magnus effect forces which propelled an endless train of cars around a closed track. Generators geared to the car axles produced electric power. An investigation has been conducted to modernize the design of and to evaluate the economic potential of a Madaras system at the present time. The investigation included a review of the major wind tunnel tests on rotating cylinders conducted since the mid 1920's and computer simulation studies of the system performance. It was found that the cylinder aerodynamic performance determined in a wind tunnel study fulfilled all expectations. Early 1934 cost estimates indicated that the Madaras system was economically competitive and the preliminary cost estimates based on the current work indicate that the Madaras system will be economical today. On the basis of an analysis it is concluded that the low-speed, high performance feature is the key to the promising potential of the Madaras concept. G.R.

**N78-24615\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**WAKE CHARACTERISTICS OF AN EIGHT-LEG TOWER FOR A MOD-0 TYPE WIND TURBINE**

Joseph M. Savino, Lee H. Wagner, and Donald Sinclair Dec. 1977 70 p refs

(Contract E(49-26)-1028)

(NASA-TM-73868; E-9463; DOE/NASA/1028-77/14) Avail: NTIS HC A04/MF A01 CSCL 10B

Low speed wind tunnel tests were conducted to determine the flow characteristics of the wake downwind of a 1/25th scale, all tubular eight leg tower concept suitable for application to the DOE-NASA MOD-0 wind power turbine. Measurements were made of wind speed profiles, and from these were determined the wake local minimum velocity, average velocity, and width for several wind approach angles. These data are presented herein along with tower shadow photographs and comparisons with data from an earlier lattice type, four leg tower model constructed of tubular members. Values of average wake velocity defect ratio and average ratio of wake width to blade radius for the eight leg model were estimated to be around 0.17 and 0.30, respectively, at the plane of the rotor blade. These characteristics suggest that the tower wake of the eight leg concept is slightly less than that of the four leg design. Author

**N78-24615\*** National Aeronautics and Space Administration.  
Lewis Research Center, Cleveland, Ohio.  
**WAKE CHARACTERISTICS OF AN EIGHT-LEG TOWER FOR  
A MOD-0 TYPE WIND TURBINE**  
Joseph M. Savino, Lee H. Wagner, and Donald Sinclair Dec.  
1977 70 p refs  
(Contract E(49-26)-1028)  
(NASA-TM-73868; E-9463; DOE/NASA/1028-77/14) Avail:  
NTIS HC A04/MF A01 CSCL 10B

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#### Wake Characteristics of an Eight-Leg Tower for a MOD-0 Type Wind Turbine.

J. M. Savino, L. H. Wagner, and D. Sinclair.  
National Aeronautics and Space Administration, Lewis  
Research Center, Cleveland, Ohio. Dec 77. 70p NASA-  
TM-73868, E-9463  
**N78-24615/4WE** Price code: PC A04/MF A01

Low speed wind tunnel tests were conducted to determine the flow characteristics of the wake downwind of a 1/25th scale, all tubular eight leg tower concept suitable for application to the DOE-NASA MOD-0 wind power turbine. Measurements were made of wind speed profiles, and from these were determined the wake local minimum velocity, average velocity, and width for several wind approach angles. These data are presented herein along with tower shadow photographs and comparisons with data from an earlier lattice type, four leg tower model constructed of tubular members. Values of average wake velocity defect ratio and average ratio of wake width to blade radius for the eight leg model were estimated to be around 0.17 and 0.30, respectively, at the plane of the rotor blade. These characteristics suggest that the tower wake of the eight leg concept is slightly less than that of the four leg design.

## ECONOMIC COMPETITIVENESS OF WINDMILLS

Ellis E. Lapin

Energy Conversion, vol. 16, no. 4, 1977, p. 213 -  
220

**Abstract**—The conditions under which windmills become competitive with the generation of electric power from fossil fuels are examined. The influence of cost of construction, financing arrangements, and the future cost of fuels is shown. Energy storage and network arrangements for mills are considered briefly, as are alternate uses for mills, e.g. the utilization of mill output directly for heating or for the production of a fuel.

77-730

**Energy from humid air.** T. K. Oliver, W. N. Groves, C. L. Gruber, and A. Cheung (South Dakota School of Mines and Technology, Rapid City, S. Dak.). *American Institute of Aeronautics and Astronautics, Thermophysics Conference, 12th, Albuquerque, N. Mex., June 27-29, 1977, Paper 77-730.* 9 p. Contract No. E(49-18)-2253.

A vast amount of energy is contained in the latent heat of vaporization of the water vapor in humid air. This paper is a report on research in progress, the goal of which is to find a cost-effective process to convert the energy in humid air into mechanical work. This would be used to drive an electrical generator. The proposed structure for converting energy from humid air is a tower similar to those used for cooling in large power plants. A proposed mechanization can be thought of as a heat engine with the air itself serving as the working fluid. The research is being carried out primarily by computer modeling, with very preliminary results presented in this paper. These results lead to tentative conclusions as to what can be done to achieve a better mechanization. Some design tradeoffs are developed. The future direction of the ongoing investigation is indicated.

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A78-40363

**Cost-effective energy from humid air.** T. K. Oliver, W. N. Groves, C. L. Gruber, and A. Cheung (South Dakota School of Mines and Technology, Rapid City, S. Dak.). In: *Recent advances in engineering science; Proceedings of the Fourteenth Annual Meeting, Bethlehem, Pa., November 14-16, 1977.* (A78-40301 17-31) Bethlehem, Pa., Lehigh University, 1977, p. 1249-1252.

A vast amount of energy is contained in the latent heat of vaporization of the water vapor in humid air. This paper is a report on research in progress, the goal of which is to find a cost-effective process to convert the energy in humid air into mechanical work. This would be used to drive an electrical generator. The research is being carried out primarily by computer modeling. (Author)



A78-22234 A wind energy conversion system based on the tracked vehicle airfoil concept. R. E. Powe (Mississippi State University, Mississippi State, Miss.). In: International Symposium on Wind Energy Systems, Cambridge, England, September 7-9, 1976, Proceedings. (A78-22226 07-44) Cranfield, Beds., England, British Hydromechanics Research Association, 1977, p. B3-39 to B3-54; Discussion, p. X27, X28. 23 refs. NSF Grant No. GI-39415.

It is pointed out that current investigations regarding wind-energy devices are either concerned with the conventional horizontal axis wind generator or with vertical axis devices. Little thoughtful effort has been devoted to the development of alternate types of devices for extraction of energy from the wind. The considered investigation was conducted to determine the technical feasibility of such an alternate wind energy conversion system. The investigated system is a novel momentum interchange device based on the tracked-vehicle airfoil concept. The system consists of airfoils mounted vertically on carriages which move around a horizontal, closed track system. It is shown that this system may possess certain significant advantages over the horizontal axis device for specific applications. G.R.

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**Energie vom Wind / herausgeber : Dr. Ulf  
Bossel. -- München : Deutsche Gesellschaft  
für Sonnenenergie e.V. (DGS), cl977.  
xii, 369 p. : ill.  
"4. Tagung am 7. und 8. Juni in Bremen."  
1. Wind power. I. Bossel, Ulf. II.  
Deutsche Gesellschaft für Sonnenenergie e.V.  
(DGS).**

The papers in this collection give descriptions of national wind energy research and development programs of various European countries, and also report on new developments in wind turbine design and wind energy system analysis. Topics covered include the wind energy programs of the Netherlands, Denmark, West Germany, and Sweden, possibilities of wind energy development in the Third World, cost analysis of horizontal-axis wind energy converters, aeroelastic problems of wind energy converters, concepts for intermediate storage of wind-produced secondary power, and costless water conveyance by wind power. P.T.H.

A79-34061 Wind energy assessment. D. M. Hardy (Solar Energy Research Institute, Golden, Colo.) and J. J. Walton (California, University, Livermore, Calif.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4. (A79-34036 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1835-1863. 17 refs. Contracts No. W-7405-eng-48; No. EG-77-C-01-4042.

Major aspects of wind energy assessment are discussed. Representative examples of modern wind turbine generators are briefly described in terms of size, power, general design, and operating characteristics. Spatial and temporal scales of wind variations and meteorological data requirements are discussed. Meteorological conditions in several coastal and mountainous areas with high wind energy densities are summarized. Methods used to map wind energy variations over the island of Oahu, Hawaii, are presented as an example of wind energy assessment in complex terrain. The study is presently documenting wind resources by means of coordinated field data collection and numerical modeling efforts. A numerical wind-field model is used to calculate three-dimensional velocities over the island. Data are collected from remote field measurement stations located to improve model input data and to provide local wind energy measurements. A statistical analysis of wind observations is used to determine predominant wind patterns. Field measurement and numerical model results obtained for Oahu, Hawaii, are given to illustrate how this general methodology might be applied to other mountainous or hilly regions. (Author)

A79-34049 Wind site selection for optimum wind power systems. M. C. Smith (Michigan State University, East Lansing, Mich.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4. (A79-34036 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1787-1808. 6 refs.

A method is given for selecting wind sites for optimum wind power systems. It is shown that in some instances the site selection is independent of the system to be used. In other instances the relative system costs of blades and electric generators will affect the site selection. Mean wind and wind distributions at sites are the significant parameters used with some discussion of other effects such as turbulence and wind profile. Two dimensionless parameters, a blade area parameter and a power parameter are developed in terms of the shaft capacity or rated wind speed and the wind speed distribution. These parameters suffice for the analysis if estimates of blade related and generator related costs can be made. (Author)

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A78-40389 New designs and applications of medium sized wind systems. D. E. Cromack and J. G. McGowan (Massachusetts, University, Amherst, Mass.). In: Recent advances in engineering science; Proceedings of the Fourteenth Annual Meeting, Bethlehem, Pa., November 14-16, 1977. (A78-40301 17-31) Bethlehem, Pa., Lehigh University, 1977, p. 1317-1326. 8 refs.

This paper presents recent developments in and applications for medium sized (10 to 100 kW) wind driven systems. Applications discussed include residential, agricultural, and commercial heating as well as hybrid electrical-thermal energy generation. The status of currently available wind turbines is given, and on-going research on wind energy systems is summarized. (Author)

**Legal-Institutional Implications of Wind Energy Conversion Systems (WECS). Final Report.**

George Washington Univ., Washington, D.C. Program of Policy Studies in Science and Technology. Sep 77. 332p  
NSF/RA-770204 Price code: PC A15

A statement of the principal overall conclusions of the Report is presented. Because of the interplay between technical, economic, social, and legal factors, some information about wind systems, their likely applications, and the problems raised thereby is presented. The most significant legal obstacles to the utilization of land-based WECS are described. The features of the existing legal structure which may facilitate the implementation of such systems are discussed. The ways in which the legal situation varies with particular applications, and which applications pose the greatest and fewest legal difficulties are summarized. A separate section is devoted to the complex subject of offshore wind systems. (ERA citation 03:023553)

**Legal-Institutional Implications of Wind Energy Conversion Systems (WECS).**

George Washington Univ., Washington, D.C. Program of Policy Studies in Science and Technology. Sep 77. 39p  
NSF/RA-770203  
PB-273 006/7WE Price code: PC A03/MF A01

The legal issues presented by wind energy conversion systems (WECS) utilization are often closely related to its structural and technological features, as well as to its economic and social implications. Some information about wind systems, their likely applications and problems, are briefly stated. The features of the existing legal structure which may facilitate the implementation of such systems are noted. The authors summarize the ways in which the legal situation varies with particular applications and which applications pose the greatest legal difficulties. The complex subject of offshore wind systems is discussed.

(DOE/NASA/1004-77/7) Brief summary of the attempts to develop large wind-electric generating systems in the U.S. Saviro, J.M. (National Aeronautics and Space Administration, Cleveland, Ohio (USA). Lewis Research Center). 1977. Contract EX-76-A-29-1004. 18p. Dep. NTIS, PC A02/MF A01.

Interest in developing large wind-electric generating systems in the United States was stimulated primarily by one man, Palmer C. Putnam. He was responsible for the construction of the largest wind-power system ever built—the 1250 kilowatt Smith-Putnam wind-electric plant. The existence of this system prompted the U.S. Federal Power Commission to investigate the potential of using the winds as a source energy. Also, in 1933 prior to Putnam's effort, there was an abortive attempt by J.D. Madaras to develop a wind system based on the Magnus effect. These three projects comprise the only serious efforts in America to develop large wind driven plants. In this paper the history of each project is briefly described. Also discussed are some of the reasons why wind energy was not seriously considered as a major source of energy for the U.S.

**Estimation of Number of Individuals Owning Wind Energy Conversion Systems. Progress Report, September 1, 1977--November 30, 1977.**

R. Ferber, and D. O'Rourke.  
Illinois Univ. at Urbana-Champaign. Dec 77. 4p  
COO/4549-1 Price code: PC A02/MF A01

The purpose of this study is to locate and interview a sample of individuals owning wind energy conversion systems (WECSs) and to obtain information about their use and experiences with setting up and operating these systems. Since no lists of such individuals are currently available, a major task of this study will involve compiling such a list, which is being done by a variety of techniques, including thus far sending letters to a large range of individuals and companies, requesting the names of any persons who may own a WECS.

TK  
7870  
.I65  
1977

**International Electrical, Electronics Conference and Exposition, [Toronto], 1977. Conference digest ... 1977] (C-2)**  
Includes bibliographical references and index.

77312	Contribution To The Development of Wind Energy Conversion Schemes, V. Rajagopalan, A. Lescarbeau, D. Veilleux, University of Quebec, Trois-Rivieres, Quebec, K 5 R 6n, Concordia University, Montreal, Quebec	216
77313	Transmission and Protection For Wind-Energy Generation Systems, S. Linke, A. Teshome, P.D. Yehsukul, Cornell University, Ithaca, N.Y.	216

**Legal-institutional implications of wind energy conversion systems (WECS).**

Washington, D.C., U.S.A., The George Washington Univ., Sep. 1977, 35pp. (PB 273 006: NSF/RA 770 203).  
Legal difficulties related to wind energy in the United States are described. These include: obstruction of wind, building codes. A section is devoted to off-shore wind energy systems. (I.F.) (Microfiche)

A control system for wind-powered generators.

Kroth, J.G.

Albuquerque, U.S.A., Sandia Labs., May 1977, 15pp.  
(SAND-77-0287).

A desirable control system for wind-powered generators would be versatile, automatic, reliable, and inexpensive. A small logic device consisting of one or a few integrated circuits which is said to meet these requirements is described. The system is versatile enough to be used over a wide range of situations which require fast, precise control. Circuit diagrams are given. (based on Author's abstract).

CN-150,180

1977

THE WIND, A LOW GRADE ENERGY SOURCE. M.A. Memarzadeh, E.I. du Pont de Nemours & Co. and T.H. Barton, Calgary Univ. (For presentation at ASME Winter Annual Meeting, Atlanta, GA, Nov.27-Dec.2, 1977). 1977. 8p.

American Society of Mechanical  
Engineers

Paper  
77-WA/Ener-4

Efforts to convert windpower into high-grade energy akin to that available at an electric wall socket or at the turn of an ignition key lead to complexity and expense. If the wind is treated as a low-grade energy source to be used as and when available, inexpensive and robust converters can be employed. The characteristics of such a system employing a simple, fixed pitch, unregulated windmill, together with electric power transmission to give a degree of siting and loading flexibility, are discussed for a variety of windmill and load types. Such a system could be employed as an energy source for remote or impoverished areas or as an alternate energy source for solar heated buildings. It is concluded that the efficiency of, and energy recovery from, a very simple fan-type windmill is almost equal to that obtained from an aerodynamically optimized one. The system has been shown to be stable for both sudden load variations and wind gusts.

## Environmental Action Reprint Series

### PLANNING A WIND POWERED GENERATING SYSTEM. by Enertech Corporation

This manual was developed to aid the layman in becoming familiar with systems components and operating principles of wind-powered systems. Chapters on basic principles, systems and components, site evaluation, power requirements, tower height, battery storage systems  
46 pages, pamphlet (4 1977) ..... \$2.00

N78-30875/ Illinois Univ., Urbana Survey Research Lab.  
PUBLIC REACTIONS TO WIND ENERGY DEVICES

Final Report

Oct. 1977 215 p. Sponsored in part by DOE  
(Grant NSF APR-75-22213)

(NSF/RA-770026) Avail: NTIS HC A10/MF A01

Reactions of the general public toward different types of wind energy devices for generating electric energy were explored. More specifically, the objectives were twofold: to provide substantive information on public acceptance of different types of wind energy devices in different settings; and to furnish a methodological base for more intensive studies of public acceptance of such devices. Personal interviews with statistical random samples of adults in six different parts of the country were conducted, with primary emphasis on rural and smaller urban areas. The locations selected were western Michigan.

Energy Storage Needs for Wind Power Systems.

J. W. Reed.

Sandia Labs., Albuquerque, N Mex. 1977, 20p CONF-770210-6

SAND-76-9058 Price code: PC A02/MF A01

Wind varies on all time scales, but hourly and longer term oscillations are most important to economic wind energy extraction schemes. Periodic variations in available wind energy, of diurnal, synoptic, annual, and larger scales, are not often correlated with demand so that some form of energy storage is needed. Most current ERDA-sponsored research in wind energy assumes connection to an existing power network and resource storage in the form of saved fossil fuels. Long term hourly wind observations at several representative U.S. locations have been used to show that a totally independent and perfectly reliable wind energy system would require an impractically large storage capacity, primarily to cover year-to-year and annual cycles of available wind energy. As reliability is allowed to decrease, a considerable reduction in storage capacity is possible. This is demonstrated by statistical results for several climatic regimes. (ERA citation 02-048285)



**Meteorological Studies for Wind Power: A Progress Report.**

J. W. Reed.

Sandia Labs., Albuquerque, N.Mex. 5 Aug 77, 13p  
CONF-770921-1

**SAND-77-1255C** Price code: PC A02/MF A01

Ten-year time series of hourly wind speed observations at fifteen selected stations have been used to generate time series of available wind power. These have been run through computer-simulated turbine systems to study long term, particularly annual and longer, variations in potential supply. These variations were so large that stand-alone generating systems would require huge, uneconomical storage capacities to provide reliable service.

Machine Design, v.49, no.18, Aug.11,1977.

**Wind energy: bounty in the breeze ..... 20**

Powerful new versions of the traditional windmill are being built. Free energy-4 looks at wind turbines that will produce up to 2.5 MW, and at advanced hardware that may bring breakthroughs in size, power, and efficiency.

**THE SPACING OF WIND TURBINES IN LARGE ARRAYS**

B. G. Newman

Energy Conversion, vol. 16, no. 4, 1977, p. 169 -  
171

**Abstract**—The effect of spacing on the power output of wind turbines in large arrays has been determined theoretically. Following Templin, the effect is assessed by determining the increase in roughness of the earth's boundary layer due to the drag of the turbines. The thickness of the boundary layer is assumed to change in proportion to the square root of the skin friction, which is appropriate for a turbulent Ekman layer, and differs from the assumptions made by Templin. The loss of power for both flat-open country and rough-wooded country is determined as a function of the area density of the turbines, and it is found that quite large spacings are required to avoid a significant loss of power.

**N78-22482** Iowa State Univ. of Science and Technology, Ames.  
**EFFECTS OF LARGE INTERCONNECTED WIND GENERATORS ON THE ELECTRIC POWER SYSTEM** Ph.D. Thesis  
David Kelly Pantalone 1977 135 p  
Avail: Univ. Microfilms Order No. 78-05986

When one considers the direct interfacing of wind generator systems (WGSs) with the electric power system, there is an interest in WGS dynamics and compatibility with the power system. Two general effects that may occur as a result of the presence of many large WGSs in the system were considered. The first effect deals with the possibility of contributing to dynamic instability in the large interconnected power system. A modal analysis of a set of WGSs on a radial line was used to examine this possibility. The effect of certain components, parameters, and conditions on the eigenvalues was studied. The second effect deals with a load tracking constraint in automatic generation control as affected by the power spectrum of the wind. A frequency response analysis was used to determine the frequency content of the WGS output. Dissertation.

**WIND ENERGY CONVERSION R & D**

Government R & D Report, Vol. VIII, No. 1  
June 15, 1977, p. 2-5

**Coupled Dynamics Analysis of Wind Energy Systems.**  
J. A. Hoffman.

Paragon Pacific, Inc., El Segundo, Calif. Feb 77, 86p  
NASA-CR-135152, PPI-1014-11  
N77-20558/1WE PC A05/MF A01

A qualitative description of all key elements of a complete wind energy system computer analysis code is presented. The analysis system addresses the coupled dynamics characteristics of wind energy systems, including the interactions of the rotor, tower, nacelle, power train, control system, and electrical network. The coupled dynamics are analyzed in both the frequency and time domain to provide the basic motions and loads data required for design, performance verification and operations analysis activities. Elements of the coupled analysis code were used to design and analyze candidate rotor articulation concepts. Fundamental results and conclusions derived from these studies are presented.

**A78-18089** A computer model for large-scale offshore wind-power systems. I. G. Dambolena (Bucknell University, Lewisburg, Pa.), R. F. Rikkers, and F. C. Kaminsky (Massachusetts University, Amherst, Mass.). *Wind Engineering*, vol. 1, no. 3, 1977, p. 163-168. 6 refs.

A computer-based planning model has been developed to evaluate the cost and simulate the performance of offshore wind-power systems. In these systems, the electricity produced by wind generators either satisfies directly demand or produces hydrogen by water electrolysis. The hydrogen is stored and later used to produce electricity in fuel cells. Using as inputs basic characteristics of the system and historical or computer-generated time series for wind speed and electricity demand, the model simulates system performance over time. A history of the energy produced and the discounted annual cost of the system are used to evaluate alternatives. The output also contains information which is useful in pointing towards more favorable design alternatives. Use of the model to analyze a specific wind-power system for New England indicates that electric energy could perhaps be generated at a competitive cost. (Author)

**A78-15783** Specific output of windmills - A discovery. E. L. Harder. *IEEE, Proceedings*, vol. 65, Nov. 1977, p. 1623-1625. 6 refs.

Because the wind varies widely from point to point on the earth it has generally been assumed that the specific output of a wind turbine generator, the kilowatt-hours generated in a year per kilowatt of rating, could only be determined from the particular wind pattern involved. However, it was discovered empirically that the specific output of windmills is practically independent of their location on the earth, or of the mean annual wind velocity. It depends instead on the ratio of the rated speed, the wind speed at which full rating is realized, to the mean annual wind velocity. This is demonstrated by data from many designs and wind-power sites. The resulting curve of specific output versus rated speed/mean annual wind velocity, together with the fundamental formula for power extracted from the wind by a windmill constitutes a useful approximate design and optimizing method. (Author)

#### Energy Analysis of a Wind Energy Conversion System for Fuel Displacement.

1977

W. D. Devine, Jr.

Institute for Energy Analysis, Oak Ridge, Tenn. Feb 77, 55p

**ORAU/IEA(M)-77-2** Price code: PC A04/MF A01

Energy conversion machines which utilize renewable supplies of energy as fuel may deliver considerably more energy to ultimate users than is consumed during manufacture, deployment, and operation of the machine. An input/output approach is employed to estimate the energy embodied in a 1,500 kW(e) horizontal-axis wind electric generating station used to displace fossil fuel in an electric utility system. Five ratios comparing delivered electrical energy to the energy requirement of the wind machine are displayed. The results indicate that the system considered could be a large net producer of energy and should displace a quantity of fossil energy equivalent to that embodied in the machine in considerably less than one year. (ERA citation 02:058923)

#### STUDY OF THE FEASIBILITY OF EXPLOITING THE GALLOPING PHENOMENON AS AN ENERGY SOURCE.

A. Laneville.

Université de Sherbrooke, Quebec, Canada.

*Transactions of the Canadian Society for Mechanical Engineering*, 1976/7, Vol. 4, 1, 23-26, (in French).

Aeroelastic galloping, or vibrations of an aerodynamically unstable prism, is studied as a potentially useful conversion mechanism for exploiting wind energy. The presence is assumed of vibration associated with vortex-shedding. The shed vortices generate oscillations of the galloping prism only when the Strouhal frequency corresponds to the prism natural frequency (at a single wind velocity). The efficiency of the mechanism is considered doubtful for the application. The orientation of the prism in a wind field constantly changing in direction, turbulence spectra, and conversion of the constant frequency generated to 60 Hz by an appropriate set of masses and springs, are considered.



TA Society of Engineering Science.  
5 Recent advances in engineering science;  
.S63 proceedings of the 14th annual meeting of  
1977 the Society of Engineering Science, Inc. /  
edited by G. C. Sih. -- Bethlehem, Pa. :  
Lehigh University, c1977.

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Includes bibliographical references and  
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1. Engineering--Congresses. I. Lehigh  
University, Bethlehem, Pa. II.

Computational analysis of windmill aerodynamics  
by R. D. Preuss and L. Morino

1253

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153 covering papers presented at the National  
.E4733 Power Engineering Society meetings."  
pt.2 1. Power resources--Congresses. 2.

Electric power--Congresses. I. IEEE  
Power Engineering Society. IEEE Power  
Generation Committee. Energy Development

Design, Economic and System Considerations of Large Wind-Driven Generators,  
by G. E. Jorgensen, M. Lotker, R. C. Meier and D. Brierley.....

Plans and Status of the NASA-Lewis Research Center Wind Energy Project,  
by R. Thomas, R. Puthoff, J. Savino and W. Johnson.....

**Coupled Dynamics Analysis of Wind Energy Systems.**  
Paragon Pacific, Inc., Feb. 77, 86p  
N77-20558/1WE PC \$5.00/MF \$3.00

A qualitative description of all key elements of a  
complete wind energy system computer analysis  
code is presented. The analysis system addresses the  
coupled dynamics characteristics of wind energy  
systems, including the interactions of the rotor, tower,  
nacelle, power train, control system, and electrical  
network. Fundamental results and conclusions de-  
rived from these studies are presented.

ORIGINAL PAGE IS  
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N78-23559\*# Kaman Aerospace Corp., Bloomfield, Conn.  
**DESIGN STUDY OF WIND TURBINES, 50 kW TO 3000 kW  
FOR ELECTRIC UTILITY APPLICATIONS: EXECUTIVE  
SUMMARY Final Report**  
Jul. 1977 95 p

(Contracts NAS3-19404; E(49-26) 1010)  
(NASA-CR-134936; R 1382; DOE/NASA/9404 7611) Avail  
NTIS HC A05/MF A01 CSCL 10A

Preliminary designs of low power (50 to 500 kW) and high  
power (500 to 3000 kW) wind generator systems (WGS) for  
electric utility applications were developed. These designs  
provide the bases for detail design, fabrication, and experimen-  
tal demonstration testing of these units at selected utility sites.  
Several feasible WGS configurations were evaluated, and the  
concept offering the lowest energy cost potential and minimum  
technical risk for utility applications was selected. The selected  
concept was optimized utilizing a parametric computer program  
prepared for this purpose. The utility requirements evaluation  
task examined the economic, operational and institutional factors  
affecting the WGS in a utility environment, and provided additional  
guidance for the preliminary design effort. Results of the  
conceptual design task indicated that a rotor operating at constant  
speed, driving an AC generator through a gear transmission is  
the most cost effective WGS configuration. Author

## VISITING WINDMILLS IN WALES.

J. Hanlon.

New Scientist, Oct. 27, 1977, p. 216-17.

Three windmills on the hilltop  
overlook what must be the largest  
collection of "alternative" technologies assembled any-  
where. They range from an entire low energy house,  
through a £2000 solar collector, to fish culture, lush organic  
gardens, and a do-it-yourself compost bin. The displays,  
along with AT homes and offices for staff, fill an aban-  
doned quarry in Machynlleth, Powys, overlooking Snow-  
donia National Park in Wales.

## Balancing power supply from wind energy converting systems.

Molly, J. P. (Deutsche Forschungs und  
Versuchsanstalt fur Luft und Raumfahrt, German  
Fed. Rep.). Wind Engng., 1, 1, 1977, pp. 57-66.

The random power fluctuation of a wind energy  
converter can be decreased by the electrical  
connection of several WECs located at large dis-  
persed sites. It is shown that such a combination  
reduces the zero output time per year and leads  
to smaller mean power fluctuations than those of  
a single WEC with an equivalent storage system.  
In addition, the way in which mean power fluc-  
tuation varies if momentary demand is chosen for  
reference is investigated. (A).

**A78-32423** Engineering of wind energy systems. J. F. Banas and W. N. Sullivan (Sandia Laboratories, Albuquerque, N. Mex.). *Wind Technology Journal*, vol. 1, Spring, 1977, p. 23-31. 11 refs.

This report addresses the engineering of wind energy systems from the point of view of component selection and performance assessment. Combinations of two load types (variable and constant speed) and three turbine types connected by a fixed-gear-ratio transmission constitute the various systems investigated. The three turbine types result from introducing the notions of nested, unnested, and hybrid power coefficients suggested by current performance characteristics of American Multiblade, Darrieus, and Darrieus/Savonius turbines. The engineering problems associated with these systems are discussed qualitatively, emphasizing the nature, magnitude, and variability of the problems. (Author)

**A78-32507** The induction generator for wind energy conversion. D. Crosno. *Wind Technology Journal*, vol. 1, Fall 1977, p. 26-30. 9 refs.

The paper describes three-phase and single-phase induction generators which could be used for converting wind energy to electricity. A safety feature of these systems, in comparison with a.c. or d.c. generators, is that if the power line voltage becomes zero, the voltage of the induction generator instantly becomes zero. Connection of a wind-driven generator to a commercial power line is considered, sample calculations of the wind speed required for producing a given power output and of the ratio of windmill torques for two loads are presented, and the importance of not using an induction motor as an induction generator, unless the motor has been designed to operate above synchronous speed, is emphasized.

(Author)

### The 'wind-wall' - an integrated wind/solar system.

McVeigh, J. C. (Brighton Polytechnic) and Pontin, G. W. W. (Wind Energy Supply Company, Peacehaven, U.K.) *Wind Engng.*, 1, 2, 1977, pp. 150-158.

This paper describes an approach to the problem of providing space and water heating to a group of local authority houses in the south of England, where there is a moderate annual wind speed, and an annular solar insolation of about  $1000 \text{ kWhm}^{-2}$  on a south facing inclined slope: the windmill system is grouped in a 'wind-wall' a new concept with fixed ducted, horizontal-axis, bi-directional windmills based on a 2m cube. (from Authors' Introduction)

**A78-32049** The production of electricity from the wind - A preliminary feasibility study for Greece. N. Galanis (Sherbrooke, Université, Sherbrooke, Quebec, Canada). *Wind Engineering*, vol. 1, no. 4, 1977, p. 241-249. 6 refs. Research supported by the Centre of Planning and Economic Research.

### A possible saturation criterion for wind energy extraction.

Railly, J. W. (Birmingham Univ., U.K.). *Wind Engng.*, 1, 1, 1977, pp. 23-35.

Two hypotheses are advanced for predicting the possible power output from a distribution of wind turbines over a large ground area. When the turbine height is small compared with the height of the planetary boundary layer, the role of shear stress in determining the power level is demonstrated and the modification to the wind structure is predicted. On this basis, realistic values of the ratio of disc area to ground area are calculated. The importance of the stability of the PBL as it affects the power level is demonstrated. (A).

**A77-48267** Wind energy - Large and small systems competing. W. D. Metz. *Science*, vol. 197, Sept. 2, 1977, p. 971-973.

Windpower, which is available on an annual basis in amounts comparable to the average energy flux of sunlight in many areas, offers one of the most inexpensive means of producing energy. The possibilities are investigated for utilizing features available in many windy regions, such as hydroelectric systems, capable of producing energy storage by holding back water while the wind is blowing, and underground gas formations, suitable for compressed air storage. Possible interference with television reception constitutes one of the major objections to wind installations, as television's synchronization speed, 30 cycles per second, is near the rotation speed of large wind systems. The use of fiber-glass blades is suggested as a partial remedy for the problem. Several existing wind machine programs are discussed with regard to construction, cost evaluation, effectiveness, and storage capacities. It is concluded that both large and small wind systems have the potential to compete with conventional electric systems.

S.C.S.

**N78-14627+** National Center for Scientific and Technical Documentation, Brussels (Belgium).

**WIND POWER SYSTEMS. A SELECT BIBLIOGRAPHY**  
Eduard H. Lapeysen, comp. Jan 1977 58 p refs  
(NCWTD-CNDST-Bib-7) Avail. NTIS HC A04

The list includes 331 reports, articles, conference papers, and other documents concerning wind energy policy, conversion, technology, and transfer. A subject index is included. ESA

A77-48896

Two general methods for the unsteady aerodynamic analysis of horizontal-axis windmills. R. D. Preuss, E. O. Suciu, and L. Morino (Boston University, Boston, Mass.). In: Intersociety Energy Conversion Engineering Conference, 12th, Washington, D.C., August 28-September 2, 1977, Proceedings, Volume 2. (A77-48701 23-44) La Grange Park, Ill., American Nuclear Society, Inc., 1977, p. 1618-1623. 11 refs. Contract No. E(49-18)-2415.

The problem of a horizontal-axis windmill embedded in incompressible, inviscid flow is considered. The vorticity field present in the undisturbed flow is assumed to be unperturbed by the presence of the windmill, enabling the use of a potential formulation. Two integral equation methods (for finite thickness and zero thickness blades) are presented. Both methods are formulated in a frame of reference rigidly rotating at constant angular velocity relative to the ground. Fully unsteady transient analysis is performed by numerical solution of the equations at discrete time steps while a simpler oscillatory unsteady analysis is performed by expressing the potential and its normal derivative as complex Fourier series in time. The wake, treated as a doublet layer, is of prescribed geometry. Numerical results are presented showing a good comparison of the methods. (Author)

**N77-31614\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

# **INVESTIGATION OF EXCITATION CONTROL FOR WIND-TURBINE GENERATOR STABILITY**

Vernon D. Gebben Aug. 1977 16 p refs

(NASA-TM-73745; E-9313; ERDA/NASA/1028-77/3) Avail: NTIS HC A02/MF A01 CSCL 10B

High speed horizontal axis wind turbine generators with blades on the downwind side of the support tower require special design considerations to handle disturbances introduced by the flow wake behind the tower. Experiments and analytical analyses were made to determine benefits that might be obtained by using the generator exciter to provide system damping for reducing power fluctuations. Author

## **TOMORROW'S WIND TURBINES BEING BUILT TODAY IN PENNSYLVANIA.**

P.B. Gipe

Alternative Sources of Energy, no.29, Dec.1977, p.5-10.

Measuring the wind conditions at a prospective site can be a complicated process. Most individuals are not able to take all of the measurements known to be important. One of the most difficult parameters to measure is the factor, alpha, or how much wind can be expected aloft. A computer

model and financial analysis were combined to see how relevant alpha is to the small wind generator user. The results obtained show that, for least cost of delivered electrical power, determination of a site's alpha by measurement is not necessary to establish optimum tower height.

## **PROGRESS ON THE KING SCHOOL WINDMILL.**

J. McGeorge.

Alternative Sources of Energy, no.29, Dec.1977, p.24-28.

John Carlson and his Senior science students formed a windmill club at King School. King School is a private institution located on a north-south ridge in the Newfield section of Stamford, CT.

The windmill was originally installed in the late 1800s as a water-pumping installation to supply water to a working farm. The location is one of the best in this area; high, clear, and rela-

tively uncluttered with trees. The prevailing winds are from the northwest in the winter and the southwest in the summer. Wind velocities are highest in the early spring and lowest in July and August.

The wind power profile for this area is such as to allow a 10 foot diameter machine to produce an average of about kilowatt hours (kwhrs) per year.

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New options in energy technology / sponsored by the American Institute of Aeronautics and Astronautics, Edison Electric Institute, IEEE Power Engineering Society. -- New York : American Institute of Aeronautics and Astronautics, c1977.

149 p. : ill. ; 29 cm.

Papers nos. 77-1004-771034

Includes bibliographical references.

1. Power resources--Research--Congresses. (Continued on card 2)

Implementation Issues of Wind Energy - U. COTY and L. VAUGHN....p. 97.

(cont.)



**A78-38781** Magdalen Islands wind turbine hybrid computer model. J. R. Amyot, R. E. Gagne, R. J. Templin, and R. S. Rangi (National Research Council, Ottawa, Canada). In: Summer Computer Simulation Conference, Chicago, Ill., July 18-20, 1977, Proceedings. (A78 38776 16-59) Montvale, N.J., AFIPS Press, 1977, p. 196-204. 5 refs.

A hybrid computer model of a 200 kW vertical axis wind turbine prototype connected to the Magdalen Island power grid by an induction generator is described. The model was implemented to obtain operational experience and uncover potential system difficulties in advance of the prototype trials. The physical system is described briefly including wind turbine rotor and spoilers, rotor/generator coupling and gearing, brake, induction generator, flywheel, start-up transformer and control, circuit breaker and power system. The mathematical model used to represent the physical system is presented using information flow diagrams followed by a description of how it was implemented on a hybrid computer including analog/digital split, digital program organization and operator interaction. Typical simulation trial results are given. (Author)

**N78-25982#** George Washington Univ., Washington, D. C. **LEGAL-INSTITUTIONAL ARRANGEMENTS FACILITATING OFFSHORE WIND ENERGY CONVERSION SYSTEMS (WECS) UTILIZATION** Final Report

Louis H. Mayo Sep. 1977 103 p refs Sponsored by DOE (Grant NSF APR-75-19137) (DOE/NSF/19137-77/3) Avail: NTIS HC A06/MF A01

Concern for the continuing sufficiency of energy supplies in the U.S. has tended to direct increasing attention to unconventional sources of supply, including wind energy. Some of the more striking proposals for the utilization of wind energy relate to offshore configurations. The legal-institutional arrangements for facilitating the utilization of offshore wind energy conversion systems were examined by positioning three program alternatives and analyzing the institutional support required for the implementation of each. Author

**N78-25983#** George Washington Univ., Washington, D. C. Program of Policy Studies in Science and Technology. **LEGAL-INSTITUTIONAL IMPLICATIONS OF WIND ENERGY CONVERSION SYSTEMS (WECS)** Final Report

Sep. 1977 332 p refs Sponsored in part by DOE (Grant NSF APR-75-19137) (NSF/RA-770204) Avail: NTIS HC A15/MF A01

Because of the interplay between technical, economic, social, and legal factors, some information about wind systems, their likely applications, and the problems raised thereby is presented. The most significant legal obstacles to the utilization of land-based WECS are described. The features of the existing legal structure which may facilitate the implementation of such systems are discussed. The ways in which the legal situation varies with particular applications, and which applications pose the greatest and fewest legal difficulties are summarized. A separate section is devoted to the complex subject of offshore wind systems.

(NSF/RA-77-0026) Public reactions to wind energy devices. Final report. (Illinois Univ., Urbana (USA). Survey Research Lab.) Oct 1977. 215p. Dep. NTIS, PC A10/MF A01.

This study was undertaken by the Survey Research Laboratory of the University of Illinois to explore reactions of the general public toward different types of wind energy devices for generating electric energy. More specifically, the objectives of the study were twofold: to provide substantive information on public acceptance of different types of wind energy devices, in different settings; and to furnish a methodological base for more intensive studies of public acceptance of such devices. The study was carried out by conducting personal interviews with statistical random samples of adults in six different parts of the country, with primary emphasis on rural and smaller urban areas. The locations selected were western Michigan, southeastern Wyoming, western Washington, eastern Rhode Island, the Chicago area, and the Sandy Hook Unit of the Gateway National Recreation Area in New Jersey. Those interviewed were questioned on a number of topics, including their attitudes toward sources of energy, their knowledge of wind energy devices, and their opinions on paying extra for pollution-free sources of energy. In addition, they were shown slides of different wind energy machines in various settings and were asked to indicate their preferences from an aesthetic point of view.

(AED-Conf-77-139-004) Wind power. Huetter, U. (Stuttgart Univ. (TH) (Germany, F.R.). Inst. fuer Flugzeugbau). 1977. 4p. (In German). Dep. NTIS (US Sales Only), PC A02/MF A01.

From Energy policies forum; Stuttgart, West Germany (9 May 1977).

A survey is presented of the possibilities to utilize wind power. In the FRG, wind power plants could meet about 70% of the electricity demand (approximately 200 TWh) on the basis of figures of 1973. Interconnected operation between wind power converters and solar energy collectors for supplying remote properties or villages seems particularly promising, too.

TJ Bereny, Justin A.

310 Survey of the emerging solar energy industry / compiled and written by Justin A. Bereny ; edited by Francis deWinter. -- 1977 ed. -- San Mateo, Calif. : Solar Energy Information Services, c1977. xi, 405 p. : ill. ; 2<sup>o</sup> cm. Bibliography: p. 369-377.

X. WIND ENERGY CONVERSION P.165-182..... 165

**N78-29590#** Georgia Inst. of Tech., Atlanta School of Aerospace Engineering.

**WIND ENERGY STATISTICS FOR LARGE ARRAYS OF WIND TURBINES, GREAT LAKES AND PACIFIC COAST REGIONS** Annual Progress Report, 1 May 1976 - 30 Apr. 1977

C. G. Justus and W. R. Hargraves May 1977 117 p refs (Contract EY-76-S-06-2439; Proj. E-16-681) (RLO/2439-77/2) Avail: NTIS HC A06/MF A01

Arrays of simulated 0.5 MW, 1.5 MW, and 2.0 MW wind turbines in the Great Lakes and Pacific Coast Regions are studied. The parameters analyzed are: basic wind statistics, time and spatial correlations, mean wind power output, wind power frequency, and run duration of wind speed and array power. New aspects include evaluation of diurnal as well as seasonal variations of wind and wind power, inclusion of density, wind shear, wind gusts and other factors in the model power output curve simulation, study of the possible relation between wind speed and degree days, and development and verification of a simplified array simulation model. ERA

Effects of wind fluctuations on windmill behaviour der Kinderen, W.J.G.J., van Meel, J.J.E.A. and Smulders, P.T. (Eindhoven Univ., Netherlands). Wind Engng., 1, 2, 1977, pp. 126-140.

A system-analytical approach is proposed to describe the output, i.e. power and forces, of a wind machine for the stochastic input signal, the wind. A simple model is presented to describe the fluctuations of wind speed and direction by means of average wind speed  $\bar{V}$  and wind direction  $\phi$ , their variances  $\sigma_v^2$  and  $\sigma_\phi^2$ , and time constants  $\tau_v$  and  $\tau_\phi$ . These input signals are used to calculate the influence of wind fluctuations on windmill performance, including the effects of non-uniformity of the flow in the rotor plane, rotor inertia and yawing of the rotor heat. Some results are given of experiments with a small (~4m diameter) 2-bladed windgenerator at the Eindhoven University of Technology. (A)

QC International Summer College on Physics and  
1 Contemporary Needs, 2d, Nathia Gali,  
.I647 Pakistan, 1977.  
1977 Physics and contemporary needs, v. 2 /  
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Wind Energy . . . . . K305-350  
P. Musgrove

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Offshore and underground power plants.  
Robert Noyes, Ed.  
Noyes Data Corp. 1977.

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#### Federal Wind Energy Program.

Energy Research and Development Administration,  
Washington, D.C. Div. of Solar Energy. 1 Jan 77, 56p  
ERDA-77-32 Price code: PC A04/MF A01

To accelerate the development, commercialization, and utilization of reliable and economically viable wind energy systems is the objective of the Federal Wind Energy Program, managed by the Wind Systems Branch (WSB) of the Energy Research and Development Administration's Division of Solar Energy. The projects being supported by the program through FY 76 are outlined. The program's general organization and the program elements which make it work are also outlined. (ERA citation 02-048271)

NASA-CP-2019

N77-30278\*# General Electric Co., Philadelphia, Pa. Space Div.

#### WIND ENERGY: A RENEWABLE ENERGY OPTION

James S. Zimmerman In NASA. Marshall Space Flight Center Proc. of the ASPE/MSFC Symp. on Eng. and Productivity Gains from Space Technol. May 1977 p 33-68 (For primary document see N77-30273 21-31)

Avail: NTIS HC A13/MF A01 CSCL 10A

CP-2019

N77-30278\*# General Electric Co., Philadelphia, Pa. Space Div.

#### WIND ENERGY: A RENEWABLE ENERGY OPTION c44

James S. Zimmerman In NASA. Marshall Space Flight Center Proc. of the ASPE/MSFC Symp. on Eng. and Productivity Gains from Space Technol. May 1977 p 33-68 (For primary document see N77-30273 21-31)

Avail: NTIS HC A13/MF A01 CSCL 10A

Wind turbine generator research programs administered by the Energy Research and Development Administration are examined. The design and operation of turbine demonstration models are described. Wind assessments were made to determine the feasibility of using wind generated power for various parts of the country. J.H.



A77-48503 Wind power - Pipe dream or reality. F. Hirschfeld. *Mechanical Engineering*, vol. 99, Sept. 1977, p. 20-28.

It has been estimated that the power which is potentially attainable from the surface winds over the U.S. is more than 30 times the probable total power consumption of the U.S. by 1980. However, attempts to utilize this resource for power-generation applications in the past have generally not been economically successful. In connection with the energy crisis, the federal government has undertaken a program for the development of economical wind systems capable of providing up to 30 years of reliable, automatic, relatively maintenance-free service. The program includes plans for the development of a 1.5-MW horizontal-axis, propeller-type experimental wind turbine generator with a composite rotor 61 m in dia. Attention is given to an experimental 100-kW unit, a review of prominent wind-power projects in the first half of the 20th century, the development and promotion of wind systems for farm and rural use, and questions of economic viability. G.R.

S-579

WINDMILLS: NTIS BIBLIOGRAPHY.  
1964-Mar.1977.

WINDPLANTS: AN INFORMAL DIRECTORY.  
Mike Evans

The Mother Earth News, No. 46, July/August  
1977, p. 34-35

Not long ago, we asked Mike Evans—the knowledgeable Editor-Publisher of *Wind Power Digest* (\$6.00/4 issues from 54468 CR 31, Bristol, Ind. 46507)—to give us a rundown of the 30 or so most active and influential windplant manufacturers, distributors, and organizations in the U.S. Mike responded by sending us the following "Informal Directory", which—although not all-inclusive—does nonetheless represent what one expert feels is a fair cross section of the industry.

A78-30197 Economic design of wind electric systems. G. L. Johnson (Kansas State University of Agriculture and Applied Science, Manhattan, Kan.). (*Institute of Electrical and Electronics Engineers, Summer Meeting, Mexico City, Mexico, July 17-22, 1977, Paper F 77 679-4.*) *IEEE Transactions on Power Apparatus and Systems*, vol. PAS 97, Mar.-Apr. 1978, p. 554-562. 9 refs.

Long term wind records are used to select the rated wind speed for wind electric generators. The wind is characterized by a Weibull density function. Detailed results are presented for western Kansas. Graphs are presented which can be used to design a wind system for maximum specific output for a specified load factor at a given site. It is shown that a wind turbine rated at a wind speed of 9 m/s has a specific output within 80% of the maximum for a wide range of wind conditions. (Author)

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Energy development III / sponsored by the IEEE Energy Development Subcommittee of the IEEE Power Generation Committee of the IEEE Power Engineering Society. — New York : Institute of Electrical and Electronics Engineers, cl977.

178 p. : ill. ; 28 cm. — (IEEE Power Engineering Society Papers ; 3)  
"77CH1215-3-PWR"

Evaluation of Wind Generator Economics in a Load Duration Context, 25...  
by B. W. Jones and P. M. Moretti.....

A78-11073 Evaluation of wind generator economics in a load duration context. B. W. Jones and P. M. Moretti (Oklahoma State University, Stillwater, Okla.). In: *Energy development III*. (A78-11069 01-44) New York, Institute of Electrical and Electronics Engineers, Inc., 1977, p. 25-29.

Wind generators used without energy storage are usually considered to compete with other generation facilities on the basis of the average incremental cost of generation. This approach can significantly underestimate the actual competitiveness of the wind generators. By analyzing the effect of the wind generators on the remaining load characteristics for an electric utility's generation system, they are shown to affect the required investment in other generation facilities considerably more than they affect operating costs. (Author)

Stochastic Modelling of Site Wind Characteristics. Final Report.

R. B. Corotis

Northwestern Univ., Evanston, Ill. Dept. of Civil Engineering Sep 77. 155p

RLO-2342-77/2 Price code: PC A08/MF A01

Statistical analysis procedures and probability models that are applicable to wind energy conversion sites in general are developed. Special computer algorithms are used to study variances, fit probability distributions, analyze run duration, and determine correlation structure in the wind. A total of 20 one-hour or three-hour records are analyzed from sites in New England, Illinois, Montana, Kansas, Wyoming, and Texas in developing and testing the models. (ERA citation 03 034940)

# THE SHROUDED AEROGENERATOR

OZER IGRA

Department of Mechanical Engineering, Ben-Gurion University of the Negev, Beersheva, Israel

(Received 4 February 1977)

**Abstract**—Experimental studies have been performed on a shrouded aerogenerator. The device tested will produce about twice the output power obtainable from an ideal wind turbine working under the same freestream conditions but without a duct. The aerogenerator does not require a driving mechanism that will keep it parallel to the free-stream direction. A simple, two-stage turbine with fixed blade geometry will provide the expected power output over a fairly wide range of free-stream velocities and rotational speeds.

## COMPACT SHROUDS FOR WIND TURBINES

Ozer Igra

Energy Conversion, vol. 16, no. 4, 1977, p. 149 - 157

**Abstract**—As part of a large project aimed at finding the optimal configuration for an aerogenerator to exploit wind power, an investigation was launched to find the most compact shroud possible. The dominant contributor to the shroud length is the structure downstream of the turbine (the diffuser). This component has an ever increasing cross-section as one progresses downstream, however, fast rate of area divergence will cause flow separation and the significant reduction in output power associated with it. It is the purpose of the present paper to demonstrate ways to overcome this difficulty. This can be achieved either by proper diversion and introduction of the shroud's external flow into the diffuser's inner boundary layer or alternatively, by the usage of a ring-flap.

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A78-40361 Vortex augmented wind energy conversion. P. M. Sforza (New York, Polytechnic Institute, Brooklyn, N.Y.). In: Recent advances in engineering science; Proceedings of the Fourteenth Annual Meeting, Bethlehem, Pa., November 14-16, 1977. (A78-40301 17-31) Bethlehem, Pa., Lehigh University, 1977, p. 1233-1236. 8 refs. Research supported by the Polytechnic Institute of New York; Contract No. E(49-18)-2358.

It is pointed out that under certain predictable conditions vortices appear in a flowing fluid. An investigation is conducted regarding the utilization of the unusual aerodynamic characteristics of vortices for the development of improved wind energy conversion systems. Key factors for such a development are related to the generation and control of discrete vortices of high power density by appropriate interaction of aerodynamic surfaces with natural winds of relatively low power density. Suitably designed turbines are used to extract energy from this compacted vortex field. The considered idea is termed the Vortex Augmentor Concept (VAC). The vortex generating surface amplifies the wind speed within the vortex field in which the swirling flow tends to concentrate the low energy flux wind from a large upstream area into a high energy flux flow in a small (vortex) area. Attention is given to VAC wind tunnel studies, the construction of a rotor test facility, and aspects of prototype development.

G.R.

## Summary of Current Cost Estimates of Large Wind Energy Systems.

JBF Scientific Corp., Washington, D.C. Feb 77, 64p  
DSE/2521-1 Price code: PC A04/MF A01

The Federal Wind Energy Program has, over the past two years, substantially extended the state of knowledge about the costs and performance of large Wind Energy Conversion Systems (WECS). Much of this progress has been achieved as a result of a series of ERDA-sponsored studies dealing with the system design, mission analysis, and regional applicability of WECS. This report reviews these studies, summarizes the most pertinent results, and provides a view of the current status and uncertainties surrounding the economics of generating energy from the wind for electric utility applications. (ERA citation 02:051389)

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A78-40366

Aerodynamic augmentation of wind turbines.

R. A. Oman and J. T. Yen (Grumman Aerospace Corp., Bethpage, N.Y.). In: Recent advances in engineering science; Proceedings of the Fourteenth Annual Meeting, Bethlehem, Pa., November 14-16, 1977. (A78-40301 17-31) Bethlehem, Pa., Lehigh University, 1977, p. 1271-1280. 11 refs. Contracts No. E(11-1)-2616; No. E(49-18)-2555.

In connection with the very low energy density of the wind and the dynamic problems associated with the use of the required large rotating elements, the employment of static surfaces as aerodynamic augmentors might become a decisive factor for a large-scale extension in the utilization of wind energy. The augmenting surfaces can reduce substantially the size and the dynamic loading of the large rotor blades necessary to produce large unit levels of power. The prospects of two augmentation concepts are investigated. In the Diffuser Augmented Wind Turbine concept, the turbine is mounted at the inlet of a diverging shroud that recovers the kinetic energy in the turbine exhaust by converting it to a pressure rise. The Tornado Wind Turbine uses the low pressure at the core of a confined vortex to provide aerodynamic augmentation for a vertical axis turbine mounted in the floor of a large hollow tower in which the vortex is established.

G.R.

**A78-32505** Toroidal accelerator rotor platforms for wind energy conversion. A. L. Weisbrich (Kaman Aerospace Corp., Bloomfield, Conn.) *Wind Technology Journal*, vol. 1, Fall 1977, p. 11-20. 9 refs.

A toroidal accelerator rotor platform (TARP) design for wind energy conversion systems (WECS) application is described and analyzed for performance and economic viability using both experimental results and analytical approaches. As an obstruction type flow concentrator and accelerator, a TARP generates low-pressure high kinetic wind-energy regions at its rotor disk sites. Since rotor performance is enhanced by flow augmentation, the calculated power output levels per unit disk area are three times the levels of conventional WECS. Advantages of TARP WECS involve reduced energy cost as well as applicability and interface adaptability to a broad range of uses, environment, and structures. The design is considered to have minimal environmental impact. M.L.

**Practical approach to vortex augmentation of wind turbines.** Pedersen, N.F. pp 19.20-19.24 of In Proceedings of the 1977 annual meeting of the American Section of the International Solar Energy Society. Volume 1, Sections 14-25. Beach, C.; Fordyce, E. (eds.). Cape Canaveral, FL; American Section of the International Solar Energy Society (1977).

From Solar world meeting; Orlando, Florida, USA (6 Jun 1977).

See CONF-770603-P2.

The case for vortex augmentation is built by reviewing the limitations imposed on the extraction of energy from the wind by means of a conventional impulse turbine. The vortex augmented reaction wind turbine is analyzed by means of the ideal gas laws and conventional empirical flow coefficients. The results are plotted to show the relations between turbine size and turbine output as a function of wind velocity. Costs of construction are estimated and the relation to turbine output shown.

**A78-18090** Betz type limitation of vortex wind machines. J. L. Loth (West Virginia University, Morgantown, W. Va.). *Wind Engineering*, vol. 1, no. 3, 1977, p. 169-185. 13 refs. Contract No. E(40-1)-5135.

Various vortex wind machines, which use a vortex generator in the form of a low aspect ratio wing or vanes in a tower, are evaluated to determine theoretical power limitations. The maximum possible power output is represented by a Betz-type dimensionless power coefficient. S.C.S.

# **Investigation of Diffuser-Augmented Wind Turbines. Part I. Executive Summary.**

R. A. Oman, K. M. Foreman, and B. L. Gilbert.  
Grumman Aerospace Corp., Bethpage, N.Y. Research  
Dept. Jan 77, 21p

**COO/2616-2(Pt.1)** Price code: PC A02/MF A01

The Diffuser Augmented Wind Turbine (DAWT) is one of the advanced concepts being investigated to improve the economics of wind energy conversion. The project is aimed at increasing the output and reducing the cost, the off-duty time, and the technical risk of wind energy conversion systems (WECS). The DAWT appears to be best suited to large WECS for commercial power production because it permits a significant increase in the unit power output without extending the size of rotating machinery into the range where rotor dynamics cause excessive costs. (ERA citation 02:051393)

**N77-31604** Grumman Aerospace Corp., Bethpage, N.Y.  
Material and Structural Mechanics.

## **A NON-AEROSPACE APPLICATION OF PLANS: PRELIMINARY STRUCTURAL DESIGN OF WIND TURBINE DIFFUSER**

J. Crouzet-Pascal Mar. 1977 88 p refs

(Contract E(11)-2616)

(RM-629) Avail: NTIS HC A05/MF A01

A baseline design for a lightweight diffuser, its calculated weight, and the method employed to calculate the specific sizes in the design are described. Formulas are presented that permit the straightforward assessment of the effect on the diffuser weight, and the related cost of power generation, of changes in dimensions, material, or allowable deflections. It was established that for a scale variation in the over-all size of the diffuser, the cost of power generation attributable to the diffuser varies linearly with the diffuser front radius. It was also established that as compared to using aluminum, the cost would actually go up with standard strength steel but down with higher strength steel. Allowing the structure to be more flexible cannot yield a reduction in cost unless a change in material properties is allowed. Author

**N78-14658** Grumman Aerospace Corp., Bethpage, N.Y.  
Research Dept.

## **INVESTIGATION OF DIFFUSER-AUGMENTED WIND TURBINES. PART 2: TECHNICAL REPORT Final Report**

R. A. Oman, K. M. Foreman, and B. L. Gilbert Jan 1977

105 p refs

(Contract EY-76-C-02-2616)

(COO-2616-2-Pt-2) Avail: NTIS HC A06/MF A01

Information on diffuser-augmented wind turbines is presented concerning the development of efficient and compact diffusers, economic analysis, and the analytical demonstration of two-stage constant speed rotor concepts. ERA



N78-14688# Grumman Aerospace Corp., Bethpage, N.Y.  
Research Dept.

**INVESTIGATION OF DIFFUSER-AUGMENTED WIND  
TURBINES. PART 1: EXECUTIVE SUMMARY**

**Final Report**

R. A. Oman, K. M. Foreman, and B. L. Gilbert Jan. 1977  
21 p

(Contract EY-76-C-02-2616)

(COO-2616-2-Pt-1) Avail. NTIS HC A02/MF A01

The Diffuser Augmented Wind Turbine (DAWT) is one of the advanced concepts being investigated to improve the economics of wind energy conversion. The project is aimed at increasing the output and reducing the cost, the off-duty time, and the technical risk of wind energy conversion systems. The DAWT appears to be best suited to large systems for commercial power production because it permits a significant increase in the unit power output without extending the size of rotating machinery into the range where rotor dynamics cause excessive costs. ERA

**MATERIALS AND PROCESSING APPROACHES TO COST COMPETITIVE WIND TURBINE ROTOR BLADES.** A study was made of materials and processes using metallics and composites or combination of both for the fabrication of low cost wind turbine blades. As a result of these studies the filament winding process was selected as offering the potential for low cost fabrication while requiring the minimum compromises in aerodynamic shape, optimum structure, and weight. A process is described which is compatible with existing winding facilities and equipment and which results in near-optimum structural fiber orientation. Fiberglass material is used with a resin system appropriate for the process and requiring minimum curing time and equipment. 3 refs.

Rothman, Edward A. (United Technol Corp. Hamilton Stand Div); Deahler, Harry E. *SAMPE Q* v 8 n 2 Jan 1977 p 13-21.

A77-48902

**Segmented and self-adjusting wind turbine rotors.** P. F. Jordan and R. L. Goldman (Martin Marietta Laboratories, Baltimore, Md.). In: Intersociety Energy Conversion Engineering Conference, 12th, Washington, D.C., August 28-September 2, 1977, Proceedings, Volume 2. (A77-48701 23-44) La Grange Park, Ill., American Nuclear Society, Inc., 1977, p. 1676-1683. 6 refs. Contract No. E(11-1)-2613.

An exploration has been made of the concept of aeroelastically self-adjusting rotor blades designed with two goals in mind: one, to keep (at constant rotor RPM) the rotor torque output essentially constant automatically over a large range of wind speeds; two, to have the unsteady aerodynamic forces act as damping forces (rather than as flutter-producing forces). Practical considerations lead to a segmented blade design. The preliminary results concerning both performance and stability of such blades are encouraging. (Author)

**THE EFFECT OF AEROFOIL CHARACTERISTICS ON WINDMILL PERFORMANCE.**

R.T. Griffiths.

University College of Swansea, Wales.

*Aeronautical Journal.* 1977, July, 322-326.

An outline of the general design procedure for a modern high speed windmill is presented along with a review of how the aerodynamic characteristics of the blade section affect the power output. The actual windmill performance is evaluated with regard to the interference factors, and the basic momentum considerations. It is shown that airfoil characteristics have small effects on planform shape and twist, but large effects on performance. Specifically, it is concluded that the maximum efficiency increases rapidly with a lift/drag ratio of up to approximately  $R = 30$ , thereafter increasing less quickly, and that the tip speed ratio also depends on the characteristic of the airfoil used.

A78-32421

**Blade twist, droop snoot, and forward spars.** J. M. Drees (Bell Helicopter Textron, Fort Worth, Tex.). *Wind Technology Journal*, vol. 1, Spring, 1977, p. 10-16. 11 refs. L.

A history of the development of some windmill blade features is presented. Evidence is provided that nonlinear blade twist and droop snoot (a sophisticated airfoil design with leading edge camber) were used in some large-diameter 17th-century windmill rotors. Location of the blade center of gravity and the main spar near the quarter chord also occurred in some large-diameter rotors of that period. The influence of Dutch windmill design on windmills constructed in areas of Dutch settlement in America is examined. M.L.

A78-32420

**Momentum theory and flow states for windmills.** F. S. Stoddard (Massachusetts University, Amherst, Mass.). *Wind Technology Journal*, vol. 1, Spring, 1977, p. 3-9. 11 refs.

The momentum theory expressions for thrust and power are discussed in relation to the various flow states which can be present on a rotor. Experience gained from helicopter and autogyro operation is used to gain understanding of the flow fields which cannot be fully described by momentum theory. Stability and control considerations are discussed in support of the emerging interest in defining suitable flight margins for wind generators.

(Author)

**N78-10625\*** United Technologies Corp., Windsor Locks, Conn.  
**DESIGN, FABRICATION, AND TEST OF A COMPOSITE MATERIAL WIND TURBINE ROTOR BLADE** Final Report  
 D. G. Griffie, Jr., R. E. Gustafson, and E. R. More Nov. 1977  
 185 p refs  
 (Contracts NAS3-19773; E(49-26)-1028)  
 (NASA-CR-135389; DOE/NASA/9773-78/1; HSER-7383)  
 Avail: NTIS HC A09/MF A01 CSCL 10A

The aerodynamic design, structural design, fabrication, and structural testing is described for a 60 foot long filament wound, fiberglass/epoxy resin matrix wind turbine rotor blade for a 125 foot diameter, 100 kW wind energy conversion system. One blade was fabricated which met all aerodynamic shape requirements and was structurally capable of operating under all specified design conditions. The feasibility of filament winding large rotor blades was demonstrated. Author

**N78-12443\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.  
**NASTRAN USE FOR CYCLIC RESPONSE AND FATIGUE ANALYSIS OF WIND TURBINE TOWERS**  
 C. C. Chamis, P. Manos, J. H. Sinclair, and J. R. Winemiller Jr.  
*In its Sixth NASTRAN Users' Colloq.* 1977 p 213-233 refs (For availability see N78-12443 03-39)  
 (Contract E(49-26)-1004)  
 Avail: NTIS HC A20/MF A01 CSCL 20K

A procedure is described which uses NASTRAN coupled with fatigue criteria via a postprocessor to determine the cyclic response and to assess the fatigue resistance (fatigue life) of wind turbine generator towers. The cyclic loads to which the tower may be subjected are entered either in a quasi-static approach through static load subcases (Rigid Format 1) or through the direct dynamic response (Rigid Format 9) features of NASTRAN. The fatigue criteria are applied to NASTRAN output data from either rigid format through an externally written user program embedded in a postprocessor. Author

## WIND TOWER HEIGHT ECONOMICS.

D. Bain.

Alternative Sources of Energy, no.29, Dec.1977,  
 p.21-23.

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Aspen Energy Forum, 4th, Aspen Institute for Humanistic Studies, 1977.

Solar architecture : proceedings of the Aspen Energy Forum 1977, May 27, 28, and 29, 1977, Aspen, Colorado / editors, Gregory E. Franta, Kenneth R. Olson ; graphics, T. Michael Manchester. — Ann Arbor, Mich. : Ann Arbor Science Publishers, c1978.  
 ix, 331 p. : ill. ; 24 cm.  
 Includes index.

WIND POWER AS A VIABLE ENERGY SOURCE . . . . . 227  
 Stan. H. Lowy

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Society of Engineering Science.

Recent advances in engineering science; proceedings of the 14th annual meeting of the Society of Engineering Science, Inc. / edited by G. C. Sih. — Bethlehem, Pa. : Lehigh University, c1977.

Held November 14-16, 1977 at Bethlehem.  
 Includes bibliographical references and index.

1. Engineering—Congresses. I. Lehigh

Computational methods of wind power flux for wind turbine design 967  
 by S. Eskinazi and A. Graham

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Society of Engineering Science.

Recent advances in engineering science; proceedings of the 14th annual meeting of the Society of Engineering Science, Inc. / edited by G. C. Sih. — Bethlehem, Pa. : Lehigh University, c1977.

Held November 14-16, 1977 at Bethlehem.  
 Includes bibliographical references and index.

New designs and applications of medium sized wind systems  
 by D. E. Cromack and J. G. McGowan

1317



**N78-23597/ Battelle Pacific Northwest Labs., Richland, Wash.  
EFFECT OF GENERALIZED WIND CHARACTERISTICS ON  
ANNUAL POWER ESTIMATES FROM WIND TURBINE  
GENERATORS**

William C. Cliff Oct. 1977 57 p refs  
(Contract EY-76-C-06-1830)

(PNL-2436) Avail: NTIS HC A04/MF A01

A technique is presented for estimating the average power output of a wind turbine using the mean annual wind magnitude. Hourly wind speeds were assumed to have a Rayleigh frequency distribution which required a single parameter input. Based upon a general shape for the wind speed versus machine output, a generic set of curves was developed to estimate the average power output of wind turbines. ERA

(BNWL/WIND-3) Survey of wind measurement field programs. Orgill, M.M. (Battelle Pacific Northwest Labs., Richland, Wash. (USA)). May 1977. Contract EY-76-C-06-1830. 60p. Dep. NTIS, PC A04/MF A01.

One of the objectives of the Wind characteristics Program Element (WCPE) is to identify and catalog existing meteorological data sets which might be used for model validation and for other Wind Energy Conversion Systems (WECS) studies. A subtask of this program of identifying meteorological data sets is the identification and cataloging of field programs that have used extensive wind measuring networks. Field programs with mesoscale wind networks are identified with data sets that might be suitable for site localization techniques. 162 references.

**Reference wind speed statistics for wind turbine design.** Justus, C.G.; Hargraves, W.R.; Mikhail, A. (Georgia Inst. of Tech., Atlanta). pp 19.11-19.15 of In Proceedings of the 1977 annual meeting of the American Section of the International Solar Energy Society. Volume 1, Sections 14-25. Beach, C.; Fordyce, E. (eds.). Cape Canaveral, FL; American Section of the International Solar Energy Society (1977).

From Solar world meeting, Orlando, Florida, USA (6 Jun 1977).

See CONF-770603-P2.

Reference or standard wind speed distribution statistics are presented based on representative low, average, and high variance cases of measured Weibull distribution parameters. Results are also presented of a sensitivity analysis of the dependence of wind turbine performance on wind turbine parameters and wind speed distribution parameters.

**A78-32504**

**How wind variability affects the potential power available from wind generators.** A. S. Konigsberg (New York, State University, New Paltz, N.Y.). *Wind Technology Journal*, vol. 1, Fall 1977, p. 8-10.

An analysis is presented to show that two different areas having the same average wind could produce significantly different amounts of power from comparable wind generator systems. Information about average wind in the area is not sufficient for prediction because of topographic and similar features. Even knowledge of the average wind speed at the precise location under consideration does not guarantee adequate predictions. The analysis explained here permits greater accuracy by taking wind variability into account. Detailed analysis of wind speed at all potential sites is recommended.

AA 1

**Locating Areas of High Wind-Energy Potential by  
Remote Observation of Eolian Geomorphology and  
Topography.**

R. W. Marrs, and J. Marwitz.

Wyoming Univ., Laramie. 1977. 23p CONF-770921-5  
RLO/2343-5 Price code: PC A02/MF A01

The purpose of research under ERDA contract EY-76-S-06-2343 is to develop an efficient procedure for inferring wind characteristics through interpretation of eolian landforms. An area in central Wyoming was chosen as the test site. The site contains many well-developed eolian landforms and is noted for its high winds. While some members of the research team interpreted satellite imagery and aerial photos and gathered field data in regions of dunes and blowouts, others compiled all available climatic information and collected additional data via low-altitude flights with a specially instrumented aircraft. Observed characteristics of eolian features were then correlated with the wind data. Cause-and-effect interrelationships were identified and theoretical models were tested as possible explanations to the observed relationships. Relationships which proved useful in the Wyoming test area were then applied over a broader region and in other areas of the country to test for regional applicability of each predictor. (ERA citation 03:017389)

**Variable speed wind turbines for high wind energy conversions.**

Kling, A. (Precessor Luftfahrzeug System, Germany). *Wind Engng.*, 1, 2, 1977, pp. 141-158.

This study compares variable speed and constant speed rotor generator systems, and shows that under certain conditions the former may extract more than twice as much useful energy as the latter.

Also suggested are a rotor configuration having less vibrational problems than the propeller and a high frequency generator specially adaptable to variable speed systems. (A)

**WIND FABRIC DIAGRAMS AND THEIR APPLICATION TO WIND ENERGY ANALYSIS.**

B.L. DAVIS, M.W. EKERN.

Institute of Atmospheric Sciences, South Dakota School of Mines and Technology, Rapid City, 57701, U.S.A.

*J. Applied Meteorology.* 1977, May, 16, 5, 522-531.

By means of the Lambert projection, wind vector data may be plotted onto a frequency map. The resulting diagram portrays the "wind-fabric" for the data sample of a single station or group of stations. By using a "swinging plate" device, the wind energy density and wind power can be calculated for any velocity-compass heading sector of the diagram. 1 table. 11 figures. 5 references.

**SOME ASPECTS OF WIND POWER STATISTICS.**

J.P. HENNESSEY, Jr.

Department of Atmospheric Sciences, Oregon State University, Corvallis 97331, U.S.A.

*J. of Applied Meteorology.* 1977, February, 16, 2, 119-128.

Some of the problems of wind power statistics are discussed. It is concluded that the most accurate method for computing the total mean wind power density, aside from using the wind observations themselves, is to use the general relationship between the expectation of the third noncentral moment and the mean, standard deviation and skewness. The Weibull model is discussed and found to be a useful tool for wind power analysis. The mean and standard deviation of the wind speed are concluded to be the minimum statistics necessary for wind power estimates. Existing studies based solely on the total mean wind power density omit much valuable information about the wind power potential of a site. 5 tables. 11 figures. 18 references.

**ESTIMATION OF WIND SPEED FREQUENCY DISTRIBUTIONS USING ONLY THE MONTHLY AVERAGE AND FASTEST MILE DATA.**

W.K. WIDGER, Jr.

Biospheric Consultants International Inc., Meredith, N.H. 03253, U.S.A.

*J. Applied Meteorology.* 1977, March, 16, 3, 244-247.

Average wind speed frequency distributions appear to be adequately approximated based on the use of only the monthly average and fastest mile data. The method is based on a square-root transformation of the speeds to an approximately normal distribution. 3 tables. 3 references.

### Wind Studies in Complex Terrain.

D. M. Hardy

California Univ., Livermore. Lawrence Livermore Lab. May 77. 39p. CONF-770539-2

UCRL-79430 Price code: PC A03/MF A01

The development and application of general methods of wind energy assessment for hilly or mountainous areas is described. The island of Oahu, Hawaii is being used as an initial study area to develop procedures useful there and in other mountainous regions. Numerical model calculations and field measurements are employed in studying the spatial and temporal variations of wind energy. Field measurement and model results show very significant wind energy spatial variations occur as a result of complex terrain. Applications of the methodology in identifying locations of wind enhancement with multi-megawatt power collection potential are described. (ERA citation 02 051410)

### WIND-ENERGY ASSESSMENT.

Energy and Technology Review, June 1977, p.18-25.

We are studying wind power on Oahu, Hawaii, to develop methods of documenting and predicting wind energy in mountainous regions.

#### SOME ASPECTS OF WIND POWER

**STATISTICS.** Some of the problems of wind power statistics are examined. The exact relationship between the mean wind speed and the mean of the cube of the wind speed is discussed. The Weibull probability density function, a good model for wind speed distributions, leads to a Weibull model for the distribution of the cube of the wind speed. This model facilitates the computation of the mean and the standard deviation of the total wind power density, the usable wind power density, and the wind power density during the hours when an aerogenerator is operating. The Weibull model is applied to data from three Oregon wind power sites located in rugged terrain. It is concluded that the mean and standard deviation of the wind speed are the minimum statistics necessary for wind power estimates, that the Weibull model for the wind power density has many computational advantages, and that the existing wind power studies based solely on the total mean wind power density omit much valuable information about the wind power potential of a site. 18 refs.

Hennessey, Joseph P. Jr. (Oreg State Univ, Corvallis). *J Appl Meteorol* v 16 n 2 Feb 1977 p 119-128.

#### ON THE ENERGY PATTERN FACTOR

**IN WIND MEASUREMENTS.** It is well known that the power present in a steady wind of speed  $v$  is proportional to the cube of the speed,  $v^3$ . It is equally well known, although rather less generally realized, that, in estimating the average power over a period of time in a given location, it is not enough to measure the average wind speed and to cube it to yield the cube of the average, since the quantity actually required is the average of the cube, and these are not identical. Measurements of energy pattern factor  $K_e$  were made using a continuous analog technique, rather than by the more usual sampling procedure. The values obtained were significantly larger than the usually accepted figure. The discrepancy is attributed partly to the method of measurement, and partly to the use of rather more typical wind speeds. 4 refs.

Buck, T.R. (New Univ of Ulster, Coleraine, North Ireland); Doherty, M.A.; McMullan, J.T.; Morgan, R.; Murray, R.B. *Int J Energy Res* v 1 n 2 Apr-Jun 1977 p 127-133.

#### WIND FABRIC DIAGRAMS AND THEIR APPLICATION TO WIND ENERGY ANALYSIS.

By means of the Lambert projection, wind vector data may be plotted onto a frequency map. The resulting diagram portrays the "wind fabric" for the data sample of a single station or for groups of stations. The area-true distribution of wind vectors is thus given in great detail and allows several standard tests for homogeneity and anomaly significance. By using a "swinging plate" device the wind energy density and wind power can be calculated for any velocity-compass heading sector of the diagram desired and allows for a universal scaling of the velocity variable of the diagram. 5 refs.

Davis, Brian L. (SD Sch of Mines & Technol, Rapid City); Ekern, Michael W. *J Appl Meteorol* v 16 n 5 May 1977 p 522-531.

(UCRL-51469(Add.)) Analysis of the winds of site 300 as a source of power. Archibald, P.B.; Knox, J.B. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 19 Apr 1977. Contract W-7405-ENG-48. 15p. Dep. NTIS, PC A02/MF A01.

Site 300 is a strategically located area lying east of the Lawrence Livermore Laboratory at Livermore, California. In a previous report, wind speed and direction for the period October 1972 to September 1973 are summarized. The present report summarizes an additional year of measurements. A comparison of the measurements shows that the annual average wind speeds for the 2 years is essentially the same; however, the monthly averages differ. These additional measurements confirm the observation that the spring and summer winds of this region have the greatest potential for wind power development.

**A78-38791** A simplified physics airflow model for evaluating wind power sites in complex terrain. R. G. Derickson (Go-Flow Consulting, Fort Collins, Colo.) and R. N. Meroney (Colorado State University, Fort Collins, Colo.). In: Summer Computer Simulation Conference, Chicago, Ill., July 18-20, 1977, Proceedings. (A78-38776 16-59) Montvale, N.J., AFIPS Press, 1977, p. 763-769. 13 refs. Contract No. EY-76-S-06-2438.

It appears that numerical simulations may provide the most accurate and economical means for the assessment of prospective wind power generation sites, especially for regions with irregular terrain. A description is presented of an airflow model which has been developed to handle arbitrary specifications of topography and a wide range of meteorological conditions. Initial results show excellent agreement with wind tunnel measurements. The model consists essentially of a fully coupled, nonlinear system of steady state momentum and energy equations in which the physics are simplified by neglecting viscosity and explicit turbulence. The two-dimensional version of the model employs a stream function-vorticity approach which is more convenient than the primitive momentum equations for 2 D. However, the 3-D version, still under development, requires use of the momentum equations since a stream function in the usual sense, does not apply to 3 D. G.R.

#### **Survey of Wind Measurement Field Programs.**

M. M. Orgill.

Battelle Pacific Northwest Labs., Richland, Wash. May 77, 60p

**BNWL/WIND-3** Price code: PC A04/MF A01

One of the objectives of the Wind characteristics Program Element (WCPE) is to identify and catalog existing meteorological data sets which might be used for model validation and for other Wind Energy Conversion Systems (WECS) studies. A subtask of this program of identifying meteorological data sets is the identification and cataloging of field programs that have used extensive wind measuring networks. Field programs with mesoscale wind networks are identified with data sets that might be suitable for site localization techniques. 162 references. (ERA citation 03:003152)

#### **Annual Report of the Wind Characteristics Program Element, April 1976--June 1977.**

J. V. Ramsdell.

Battelle Pacific Northwest Labs., Richland, Wash. Jul 77, 138p

**BNWL/WIND-10** Price code: PC A07/MF A01

Battelle, Pacific Northwest Laboratories (PNL), has been providing technical and management support for the Wind Characteristics Program Element (WCPE) of the Wind Energy Conversion Program since April 1976. This first annual report to the Wind Systems Branch (WSB) of ERDA's Division of Solar Energy describes the technical progress within the Program Element from April 1976 through June 1977. Within the Wind Energy Conversion Program, the WCPE is a service element to provide information on wind characteristics to those involved in energy program planning, design and evaluation of performance of wind energy conversion systems (WECS), selection of sites for installation of WECS, and operation of WECS. To identify pertinent wind characteristics and collect and present that information in formats that are usable, the WCPE has been divided into four technical areas: Design and Performance Evaluation; Site Selection; Presiting Evaluation; and Planning and Operation. (ERA citation 03:017380)

**N78-19616\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### **WIND TURBINE STRUCTURAL DYNAMICS**

Dean R. Miller, ed. 1978 280 p refs Workshop held at Cleveland, 15-17 Nov. 1977; sponsored by DOE

(NASA CP-2034; DOE-Conf-771148; E-9518) Avail: NTIS HC A13/MF A01 CSCL 10A

A workshop on wind turbine structural dynamics was held to review and document current United States work on the dynamic behavior of large wind turbines, primarily of the horizontal-axis type, and to identify and discuss other wind turbine configurations that may have lower cost and weight. Information was exchanged on the following topics: (1) Methods for calculating dynamic loads; (2) Aeroelasticity stability (3) Wind loads, both steady and transient; (4) Critical design conditions; (5) Drive train dynamics; and (6) Behavior of operating wind turbines. For individual titles, see N78-19617 through N78-19641.



**Wind Energy Conversion Systems Manufacturing and Sales Activity, 1975 and 1976.**

Norbert Parker, and Howard Walton.

Federal Energy Administration, Washington, D.C. Office of Coal, Nuclear, and Electric Power Analysis. Apr 77. 11p

FEA/B-77/121

PB-265 823/SWE. Price code: PC A02/MF A01

This report contains the results of an annual survey of private firms engaged in the manufacturing and distribution of wind energy conversion systems in the United States during the years 1975 and 1976. Imports of systems manufactured abroad for distribution in the United States are also included.

**Control System for Wind-Powered Generators.**

G. J. Kroth.

Sandia Labs., Albuquerque, N.Mex. May 77. 15p

SAND-77-0287 Price code: PC A02/MF A01

In a system of wind-powered generators, a reliable yet inexpensive control system is desirable. Such a system would be completely automatic so it could be left unattended for long periods. It would respond to electrical representations of data such as bearing temperature, vibration, wind velocity, turbine velocity, torque, or any other pertinent data. It would respond by starting or stopping the turbine, controlling the loading, or sounding an alarm. A microprocessor-based controller capable of these functions is described. (ERA citation 02:048286)

- QA Annual review of fluid mechanics. v. 9 /  
911 Milton Van Dyke, J. V. Wehausen, John L.  
.A6 Lumley, editors. -- Palo Alto, Calif. :  
v.9 Annual Reviews, 1977.  
509 p. : ill. ; 23 cm.  
Includes bibliographical references and  
index.  
ISBN 0-8243-0709-7  
1. Fluid mechanics--Yearbooks. I. Van  
Dyke, Milton, ed. II. Wehausen, J. V., ed.  
III. Lumley, John L., ed.

OPTIMUM WIND-ENERGY CONVERSION SYSTEMS. Ulrich Hutter

199

A78-30863 Oklahoma State Univ., Stillwater.

**TRANSIENT BEHAVIOR OF WIND DRIVEN SYNCHRONOUS MACHINES Ph.D. Thesis**

Abdul Qavi Qazi 1977 155 p

Avail: Univ. Microfilms Order No. 7811064

The transient behavior of wind driven synchronous machines under conditions of wind gusts and faults for various system configurations were investigated and design recommendations from the view point of electrical stability and energy delivered to the utility grid were made. This task was performed in the following steps: (1) formulate the mathematical model for each identified and selected system configuration, (2) solve the sets of non-linear differential equations by employing an appropriate numerical technique and digital simulation, (3) present the results in the form of curves (4) interpret these curves, (5) draw some useful conclusions and (6) suggest areas for future research work.

Dissert. Abstr.

A78-18053

Generation of electricity from the wind. D. F.

Warne and P. G. Calnan (Electrical Research Association, Ltd., Leatherhead, Surrey, England). *IEE Reviews*, vol. 124, Nov. 1977, p. 963-985. 121 refs.

The paper outlines the present status of wind power, its technology, and potential in various applications with special emphasis on electricity generation. Topics reviewed include the availability of wind energy, fundamental wind-turbine theory, design options, practical plant achievements, major projects in progress in various countries, and wind-power economics. Wind-turbine performance prediction is discussed relative to simple momentum theory, types of wind turbine, lift and drag in airfoil sections, and operation of high-speed vertical-axis turbines. Possible applications of wind-driven plants are assessed, and potential contributions to future energy needs are projected.

S.D.

**A theory and experimental investigation of ducted wind turbines.**

Lewis, R. I., Williams, J. E. and Abdellghaffar, M. A. (Newcastle upon Tyne Univ.) *Wind Engng.*, 1, 2, 1977, pp. 104-125.

Following a general introduction this paper on ducted wind turbines opens with a section summarising the main effects of surrounding a wind turbine rotor with a suitably shaped cowl or duct.



TJ  
153  
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Energy development III ... cl'77. (Card 2)  
Includes bibliographic references.  
1. Power resources—Congresses.  
2. Electric power—Congresses. I.  
IEEE Power Engineering Society. IEEE  
Power Generation Committee. Energy Develop-  
ment Subcommittee. II. Series.

Control and Dynamic Analysis of a Wind Energy Conversion and Storage System  
Operating at Constant Velocity Ratio, by H. R. Sinkovits and J.G. Kassakian  
p. 48

TJ  
153  
.E4783  
pt.3  
Energy development III / sponsored by the IEEE  
Energy Development Subcommittee of the IEEE  
Power Generation Committee of the IEEE Power  
Engineering Society. -- New York : Institute  
of Electrical and Electronics Engineers,  
cl'77.  
178 p. : ill. ; 28 cm. -- (IEEE Power  
Engineering Society Papers ; 3)  
"77CH1215-3-PWR"

Evaluation of Offshore Site for Wind Energy Generation,  
by H. S. Kirschbaum, E. V. Somers, and V. T. Sulzberger... p. 108...

A78 22233 A cross flow wind turbine M. J. Holgate  
(Durham, University, Durham, England). In: International Symposi-  
um on Wind Energy Systems, Cambridge, England, September 7-9,  
1976. Proceedings. (A78 22226 0744) Cranfield, Beds., England,  
British Hydromechanics Research Association, 1977. p. 82-29 to  
B2-38; Discussion, p. X25-X27.

A theoretical analysis is presented of the operation of a type of  
crossflow turbine that depends for its action on angular momentum  
conversion rather than aerodynamic lift. Experimental results con-  
firm the theoretical predictions to a satisfactory degree. These are,  
that while the turbine does develop a starting torque and has a stable  
torque-speed characteristic, it runs at low velocity ratio and has a low  
efficiency of energy conversion. (Author)

A79-34050 A review of wind-electric conversion technolo-  
gy. R. Ramakumar (Oklahoma State University, Stillwater, Okla.).  
In: Alternative energy sources. Proceedings of the Miami Interna-  
tional Conference, Miami Beach, Fla., December 5-7, 1977. Volume  
4. (A79 34036 1344) Washington, D.C., Hemisphere Publishing  
Corp., 1978. p. 1811-1834. 28 refs. Research supported by the  
Oklahoma State University and U.S. Department of Energy.

This paper presents a review of the major generation schemes  
proposed for wind to electrical conversion and discusses their merits  
and demerits in the context of energy collection, cost, operation,  
control and utilization. The size of the system and the nature of the  
wind regime strongly influence the type of generation scheme that  
will lead to cost effectiveness. With medium (50 to 250 kW) and  
large (above 250 kW) systems, cost of the electrical generator is  
expected to be only a small fraction (about ten percent) of the  
overall cost. Therefore, a significant percentage increase in the  
generator system cost can be justified if it results in a decrease in the  
cost of other components and/or increase the energy collection  
efficiency, leading to a lower cost for wind generated electrical  
energy. (Author)

A79-14771 # Feature review of some advanced and innova-  
tive design concepts in wind energy conversion systems. A. L.  
Weisbrick (Kaman Aerospace Corp., Bloomfield, Conn.). In: Miami  
International Conference on Alternative Energy Sources, Miami  
Beach, Fla., December 5-7, 1977. Proceedings of Condensed Papers.  
(A79-14760 0344) Coral Gables, Fla., University of Miami, 1978. p.  
847-859. 21 refs.

Several advanced wind energy conversion system concepts are  
presented in terms of principles of operation, advantages claimed or  
anticipated, and areas of concern. Consideration is given to the  
following systems: (1) Darrieus vertical axis, (2) diffuser augmented  
wind turbine, (3) tornado type, (4) windmill with tip vanes, (5) wind  
tip vortex concentrator, (6) vortex augmentor, (7) cylindrical  
Darrieus rotor, (8) variable geometry vertical axis windmill, (9)  
gromill, (10) precursor system, (11) tracked vertical airfoil, (12)  
cylindrical obstruction type concentrator, and (13) TARP. B.J.

NA Davis, Albert J.

2542.3 Alternative natural energy sources in  
.D38 building design / Davis & Schubert. — New  
1977 York : Van Nostrand Reinhold, [1977], c1974.

252 p. : ill. ; 22 x 28 cm.

- SIX WIND POWER..... 101  
6.1 Power available  
from the wind..... 103  
6.2 Wind velocities  
on site..... 103  
6.3 Components of a  
wind generated  
power plant..... 105

#### WIND POWER FOR HOME HEATING

E.F. Lindsley

Popular Science

Vol. 211, no. 5, November 1977,

p. 62-66. What's the least costly and most effective way to use the wind's erratic power? The direct production of heat by churning confined air, thinks Clarence Kenney, 72-year-old retired turbine engineer, who has spent the past several years developing and testing such a wind-powered heating system for his home.

N77-33862/ Princeton Univ., N. J. Dept. of Aerospace and Mechanical Sciences.

OPTIMIZATION AND CHARACTERISTICS OF A SAILWING  
WINDMILL ROTOR Final Report, 1 Feb. 1976 - 31 Jan.  
1976

M. D. Maughmer 31 Jan. 1976 86 p refs Sponsored in  
part by ERDA

(Grant NSF GI-41891)

(NSF/RANN/GI-41891/FR/75/4)

Avail: NTIS

HC A05/MF A01

A detailed accounting of the development and operational techniques of the Princeton moving vehicle windmill testing facility is presented. Also presented is a complete documentation of the performance build-up of a 12 foot diameter, two bladed Sailwing rotor. An examination of an exploratory research effort directed toward using a small, first stage, co-axial rotor to augment windmill performance is included. Finally considered are the results and conclusions of an extensive wind tunnel test program aimed at a quantitative determination of the aerodynamic penalties associated with numerous simplifications of the basic double membraned Sailwing cross section. ERA

#### Electrofluid Dynamic (EFD) Wind Driven Generator. Final Report, September 1, 1975--September 15, 1976.

J. E. Minardi, M. O. Lawson, and G. Williams.

Dayton Univ., Ohio. Research Inst. Oct 76, 90p

ERDA/NSF/00931-76/T1, UDRI-TR-76-67, NSF/RA-761350

COO/4130-77/1 Price code: PC A05/MF A01

The study and testing of an electrofluid dynamic (EFD) wind driven generator are reviewed. The EFD wind driven generator directly converts wind energy to electrical energy without moving parts except, possibly, for directing it into the wind. A theoretical analysis is presented of the EFD wind driven generator, including a computer study of electric field geometry and an analysis of charged colloid production requirements. Experimental data obtained with the EFD test rig and a small wind tunnel designed and built for this program are described. Future plans are also detailed. (ERA citation 03:000557)

TA 5 .S63 1977 A78-40362 Electrofluid dynamic /EFD/ wind driven generator research. J. E. Minardi and M. O. Lawson (Dayton, University, Dayton, Ohio). In: Recent advances in engineering science; Proceedings of the Fourteenth Annual Meeting, Bethlehem, Pa., November 14-16, 1977. (A78-40301 17-31) Bethlehem, Pa., Lehigh University, 1977, p. 1237-1247. 10 refs. Contract No. E(11-1)-4130.

The theory of electrofluid dynamic (EFD) wind generators is based on an intimate combination of aerodynamic and electrical considerations. It has been shown by Minardi (1966) that a successful EFD generator must use colloid particles to achieve reasonable efficiencies. The basic equations of the theory constitute a combination of the relations of the ideal wind converter theory provided by Betz (1927) and the one-dimensional EFD theory developed by Lawson et al. (1961) for charged particles. The performance of the EFD wind generator as a function of mobility is shown in a graph. The performance characteristics for an EFD wind driven generator made of 1 ft tubes are also presented and attention is given to a computer study of suitable EFD wind generator configurations. G.R.

TJ 810 .S48 1976 v.7 Agriculture, biomass, wind, new developments : joint conference, American Section, International Solar Energy Society and Solar Energy Society of Canada, inc., August 15-20, 1976, Winnipeg / editor, K. W. Roer. — Cape Canaveral, Fla. : American Section of the International Solar Energy Society, c1976.

O. D. Sittler ENERGY CONTENT OF WINDS IN THE HIGH PLAINS 243 REGION OF SOUTHWESTERN U.S.

ABSTRACT: Winds at Portales, New Mexico are being studied to assess the amount of wind energy available and its distribution in time. The analysis includes the effect of short-term variations in wind speed, or gusts, in the calculation of total energy content. Data collected between November, 1975 and April, 1976 indicate that average wind speed exceeds 4.5 m/sec (10 MPH) for 9.6 hrs/day on the average. During these hours, the average energy flux per day is about 2.2 kwhr per square meter. Sequences of 4 or 5 days having energy flux less than 1.0 kwhr per square meter seldom occur; thus, wind could supply energy in this region on a regular basis with the help of energy storage or through procedures which match energy demand to times when wind energy is available. Data collected at this site probably apply to a large area in the high plains region of Southwestern United States.

A77-49091 Wind energy statistics for large arrays of wind turbines - New England and Central U.S. regions. C. G. Justus (Georgia Institute of Technology, Atlanta, Ga.). In: Sharing the sun: Solar technology in the seventies; Proceedings of the Joint Conference, Winnipeg, Canada, August 15-20, 1976. Volume 7. (A77-48910 23-44) Cape Canaveral, Fla., International Solar Energy Society, 1976, p. 268-288. NSF Grant No. GAER-75-00647; Contract No. E(40-1)-5108.

The performance characteristics have been simulated for large dispersed arrays of 500 kW-1500 kW wind turbines producing power and feeding it directly into the New England or Central U.S. utility distribution grids. These studies show that in good wind environments the 500 kW generators can average (on an annual basis) up to 240 kW mean power output, and the 1500 kW generators can average up to 350 kW mean power output. Better performance (averaging up to 470 kW) is obtained, however, by an 1125 kW rated power unit designed to operate at lower wind speeds. The beneficial effect of operating large dispersed arrays of wind turbines is that available power output can be increased - if winds are not blowing over one part of the array, chances are they will over some other part of the array. These studies indicate that wind power availability levels of 200 kW per 1125 kW generator were 77% to 93%, depending on season. Reasonably steady high wind power in winter and high afternoon peak wind power in summer (corresponding to peak air conditioning load) means that significant peak load dispersment can be achieved without use of storage. (Author)

#### Wind Energy Mission Analysis. Final Report.

U. A. Coty.  
Lockheed-California Co., Burbank. Sep 76. 608p  
SAN/1075-1/1 Price code: PC A99/MF A01

Maps of wind power densities are presented covering the United States and Territories. Each region is assessed in terms of available wind power, its distribution over the land, and its frequency, deviation, and strength. A matrix of energy users and their applications of wind energy conversion systems is assembled and evaluated to select those combinations which have the highest potential in terms of nationwide impact. The high potential applications are analyzed in depth to determine degree of market penetration, performance and cost goals, marketing channels, incentives to implementation, and institutional constraints. An initial assessment of public acceptance was performed during the course of the study which is analyzed and reported. Widely varying scenarios are postulated to develop extreme, yet possible, limits of implementation rates. The effects of these implementation rates are determined as they pertain to production rates, supply of critical materials, land usage, capital requirements, environmental pollution, electrical energy generated, fossil fuel saved, balance of trade, net flow of free energy, and energy payback time. (ERA citation 02:058924)

**Wind Energy Mission Analysis. Appendix.**

Lockheed-California Co., Burbank. Apr 76. 268p  
SAN/1075-1/2 Price code: PC A12/MF A01

Appendices include information on the average power density of the wind for the U.S. and its territories, characteristics of the vertical axis machine, structural analysis details, aerodynamic analysis, cost factors for WTG cost model, evaluation of utility applications, industrial cost of electricity, national impact of WECS, public acceptance, and environmental issues. (ERA citation 02 058925)

**Wind Energy Mission Analysis. Executive Summary.**

Lockheed-California Co., Burbank. Oct 76. 32p  
SAN/1075-1/3 Price code: PC A03/MF A01

The Wind Energy Conversion Branch of The Energy Research and Development Administration, undertook the task of determining the economic viability of wind energy conversion systems (WECS). A contract, AT(04-3)-1075 "Wind Energy Mission Analysis," was awarded to Lockheed early in 1975 and completed early in 1976. The results of this study are condensed and summarized in this executive summary to provide an overview of over 850 pages of report and appendices and over 1,000 pages of processed wind data. (ERA citation 03:017383)

**Development of a Wind Energy Site Selection**

**Methodology. Progress Report, 3 May--3 December 1976.**  
B. E. Freeman, P. C. Patnaik, and G. T. Phillips.  
Science Applications, Inc., La Jolla, Calif. 1976. 152p  
RLO/2440-76/4 Price code: PC A08/MF A01

The components of the site selection methodology, and the method of Empirical Orthogonal Eigenfunctions for the identification of recurrent meteorological patterns in the climatological data are described. Several faster meteorological computer codes are compared. The further development and testing of the primitive equation models (the SIGMET family of codes) are described. This consists of developments which will permit calculations to be performed more rapidly (through partial implicitization) and more accurately (through improved physical models). (ERA citation 02 058939)

**Sites for Wind Power Installations: Wind Tunnel Simulation of the Influence of Two-Dimensional Ridges on Wind Speed and Turbulence. Tabulated Experimental Data. Progress Report, June--November 1976.**

R. N. Meroney, V. A. Sandborn, R. J. B. Bouwmeester, and M. A. Rider.

Colorado State Univ., Fort Collins. Dept. of Civil Engineering. Dec 76. 70p

RLO/2438-76/1 Price code: PC A04/MF A01

In the second part of the report on the wind field developed over two dimensional model hills experimental data are presented in tabular form. The objective of this research was to increase technical capacity to locate favorable wind system sites, reduce uncertainty in the prediction or validation of the characteristics of sites, and thus assist in the sizing and performance prediction of wind systems. The research included evaluation of low speed aerodynamics over terrain and boundary flow conditions over ridges by means of wind tunnel modeling. Measurements reported have been completed over triangular and sinusoidal shape hills of wind speed, static pressure variation, and turbulence intensity. Hill aspect ratios studied range from exp 1 / sub 2 to exp 1 / sub 6 with some data available at exp 1 / sub 20. (ERA citation 02 051409)

**N77-22619/ Battelle Pacific Northwest Labs., Richland, Wash. MATHEMATICAL MODELING OF TOPOGRAPHIC EFFECTS OF WIND ENERGY SYSTEMS**

B. E. Freeman. Apr. 1976. 26 p. ref. Presented at Intern. Symp. on Wind Energy Systems, Cambridge, UK, 7 Sep. 1976. (Contracts E(45-1)-1830. NSF C 1006. Grant NSF AER-75-00834) (BNWL SA-5935. Conf-760909-3) Avail: NTIS HC A03/MF A01

Meteorological phenomena taking place in regions comparable to the distance between synoptic weather stations (approximately 200 km) and in the immediate vicinity of the windmill site (approximately 1 km) are considered. Computer codes were developed for each of these regimes, and calculations of wind flow over complex terrain have been performed. Results of some of the wind calculations are presented, illustrating the effects of terrain on wind energy potential. ERA



A77-49093

**Diffuser augmentation of wind turbines.**

K. M. Foreman, B. Gilbert, and R. A. Oman (Grumman Aerospace Fluid Dynamics Laboratory, Bethpage, N.Y.). In: *Sharing the sun: Solar technology in the seventies; Proceedings of the Joint Conference, Winnipeg, Canada, August 15-20, 1976*. Volume 7. (A77-48910 23 44) Cape Canaveral, Fla., International Solar Energy Society, 1976, p. 304-316. 9 refs. Contract No. E(11-1) 2616.

The Diffuser Augmented Wind Turbine (DAWT) is an advanced concept for reducing the cost per output KW-hr of windpower. The diffuser controls the expansion of turbine exhaust flow, producing a highly subatmospheric pressure at the turbine exit; the low static pressure induces greater mass flow through the turbine vs a conventional turbine design of the same diameter. Two cost-effective model configurations were examined in the wind tunnel: one uses the energetic external wind to prevent separation of the diffuser's internal boundary layer, while the other uses high lift airfoil contours for the diffuser wall shape. The wind tunnel tests have indicated almost a doubling of wind power extraction capability for DAWTs compared to conventional turbines. B.J.

A77-48899

**Fluid dynamics of diffuser augmented wind turbines.**

B. L. Gilbert, R. A. Oman, and K. M. Foreman (Grumman Aerospace Fluid Dynamics Laboratory, Bethpage, N.Y.). In: *Inter-society Energy Conversion Engineering Conference, 12th, Washington, D.C., August 28-September 2, 1977, Proceedings*. Volume 2. (A77-48701 23 44) La Grange Park, Ill., American Nuclear Society, Inc., 1977, p. 1651-1659. 6 refs. Contract No. E(11-1) 2616.

The Diffuser Augmented Wind Turbine (DAWT) is one of the advanced concepts being investigated to improve the economics of wind energy conversion systems (WECS). Application of modern boundary layer control techniques has reduced the surface area requirements of an efficient diffuser by an order of magnitude. Many parameters that effect the performance of the diffuser system have been examined in small scale wind tunnel tests with a family of compact diffusers, using screens and centerbodies to simulate the presence of a turbine. Flow field surveys, overall performance, the effect of ground proximity, and the prospects for further improvement are described. The baseline configuration is a conical, 60 deg included angle diffuser with an area ratio of 2.78 controlled by two tangential injection slots. This first generation DAWT can provide about twice the power of a conventional WECS with the same turbine diameter and wind. Economic estimates show that this DAWT can be as much as 50% cheaper than conventional WECS for the same rated power. (Author)

**Aerodynamic performance of wind turbines.**

Wilson, R.E., Lissaman, P.B.S. and Walker, S.N. *Oregon State Univ., U.S.A., Jun. 1976, 184pp. (NSF/RA-760 228). (PB-259089).*

This report summarizes the state-of-the-art of performance prediction methods for both horizontal and vertical axis wind turbines. Strip theory methods for horizontal axis wind turbines are evaluated for various tip loss models. A comparison of these tip models is developed for the ERDA-NASA MOD-O rotor. The occurrence of multiple solutions in strip theory analysis is discussed and illustrated. The performance of high-solidity turbines such as the Chalk design also is discussed. The configuration and performance of optimum horizontal axis wind turbines are addressed. Optimization schemes are developed and discussed and comparisons with the MOD-O rotor are made. Performance at off-design conditions is also examined. The final two chapters deal with performance prediction methods for vertical axis wind turbines: Chapter 4 develops the performance model for the Darrieus Rotor.

**N78 23560\*# Kaman Aerospace Corp., Bloomfield, Conn. DESIGN STUDY OF WIND TURBINES 50 kW TO 3000 kW FOR ELECTRIC UTILITY APPLICATIONS: ANALYSIS AND DESIGN Final Report**

Feb. 1976 567 p refs  
(Contracts NAS3-10094; E(49-26) 1010)  
(NASA-CR-134937; R-1382; DOE/NASA/9404-76/2) Avail:  
NTIS HC A24/MF A01 CSCL 10A

In the conceptual design task, several feasible wind generator systems (WGS) configurations were evaluated, and the concept offering the lowest energy cost potential and minimum technical risk for utility applications was selected. In the optimization task, the selected concept was optimized utilizing a parametric computer program prepared for this purpose. In the preliminary design task, the optimized selected concept was designed and analyzed in detail. The utility requirements evaluation task examined the economic, operational, and institutional factors affecting the WGS in a utility environment, and provided additional guidance for the preliminary design effort. Results of the conceptual design task indicated that a rotor operating at constant speed, driving an AC generator through a gear transmission is the most cost effective WGS configuration. The optimization task results led to the selection of a 500 kW rating for the low power WGS and a 1500 kW rating for the high power WGS. Author



**N77-22637#** Energy Research and Development Administration, Washington, D.C.

**COMPARISON OF DIFFERENT WIND ENERGY CONVERSION SYSTEMS. PART 1: THE NOAH SYSTEM COMPARED WITH THE ULRICH HUTTER SYSTEM**

1976 10 p refs

(Contract E(29-2)-3533)

(RFP-Trans-204-Pt-1) Avail: NTIS HC A02/MF A01

The analysis is made within the framework of structural components which are generally important for wind energy systems. Advantages and disadvantages are evaluated from technical viewpoints (type of construction, novelty, susceptibility to failure, ease of repairs, maintenance requirements), as well as in terms of expected power, performance, manufacturing cost and economy. ERA

**N77-24620#** Societal Analytics Inst., Inc., Dallas, Tex.

**BARRIERS TO THE USE OF WIND ENERGY MACHINES:**

**THE PRESENT LEGAL/REGULATORY REGIME AND A PRELIMINARY ASSESSMENT OF SOME LEGAL/POLITICAL/SOCIETAL PROBLEMS**

Rita Falk Taubenfeld and Howard J. Taubenfeld Jul. 1976 159 p refs

(Grant NSF AER-75-18362)

(PB-263576/1; NSF/RA-760422)

Avail: NTIS

HC A08/MF A01 CSCL 10B

The present state of law and regulation at all levels of government that may affect wind energy machines is analyzed. Also analyzed and assessed is the state of analogous and related law and regulation, requirements at various levels of government, and international rules, as wind machines grow larger and/or are used in arrays. It suggests some potential impacts of the development of wind-based power technology on selected aspects of the American economy, particularly on the energy delivering utilities. GRA

**TJ810.548 1976 V.7**

**A77-49087**

Wind-electric conversion utilizing field modulated generator systems. R. Ramakumar (Oklahoma State University, Stillwater, Okla.). In: Sharing the sun: Solar technology in the seventies; Proceedings of the Joint Conference, Winnipeg, Canada, August 15-20, 1976. Volume 7. (A77-48910 23-44) Cape Canaveral, Fla., International Solar Energy Society, 1976, p. 215-229. 24 refs. ERDA-supported research; NSF Grant No. AER-75-00647.

Variable-speed constant-frequency wind-electric systems operate at a constant tip speed ratio with varying wind speeds and enable the extraction of a part of the energy spilled by constant-speed constant-frequency systems. This paper describes the variable-speed constant-frequency wind-driven field modulated generator system under development at Oklahoma State University, sponsored by ERDA/NSF. Proposed control schemes and the experimental research program underway are briefly discussed. These systems appear to be most attractive in the 'small' (10 to 50 kW) and '100 kW scale' (50 to 250 kW) sizes and for use in large capacity 'multirotor on one tower' concepts. (Author)

**N78-12529#** General Electric Co., Philadelphia, Pa. Valley Forge Space Center.

**DESIGN STUDY OF WIND TURBINES 50 kW TO 3000 kW FOR ELECTRIC UTILITY APPLICATIONS. VOLUME 1: SUMMARY REPORT Final Report**

Sep. 1976 65 p

(Contracts NAS3-19403; E(49-26)-1010)

(NASA-CR-134934; ERDA/NASA-94J3-76/1-Vol-1;

Doc-SDS4287-Vol-1) Avail: NTIS HC A04/MF A01 CSCL 10B

Wind turbine configurations that would lead to generation of electrical power in a cost effective manner were considered. All possible overall system configurations, operating modes, and subsystem concepts were evaluated for both technical feasibility and compatibility with utility networks, as well as for economic attractiveness. A design optimization computer code was developed to determine the cost sensitivity of the various design features, and thus establish the configuration and design conditions that would minimize the generated energy costs. The preliminary designs of both a 500 kW unit and a 1500 kW unit operating in a 12 mph and 18 mph median wind speed respectively, were developed. The rationale employed and the key findings are summarized. Author

**TJ810.548 1976 V.7**

**A77-49090**

The use of built form to enhance the output of wind collectors. D. R. Coonley (Design-Research-Consulting, Harrisville, N.H.). In: Sharing the sun: Solar technology in the seventies; Proceedings of the Joint Conference, Winnipeg, Canada, August 15-20, 1976. Volume 7. (A77-48910 23-44) Cape Canaveral, Fla., International Solar Energy Society, 1976, p. 253-267. 14 refs.

Buildings often give rise to extreme wind velocities at ground level, especially when there is an open area for the wind to pass through. This paper considers the possibility of utilizing the wind ducting capabilities of built structures in an attempt to gain better use of and increased energy output from wind energy conversion systems. Attention is given to the integration of wind collector systems with buildings. The variation of fixed wind collector output with variation in wind direction is studied and methods for reducing wind problems around buildings are examined. B.J.

**N77-33867#** Massachusetts Inst. of Tech., Cambridge. Aerelastic and Structures Research Lab. **WIND ENERGY CONVERSION Final Report. Feb. 1976 - Oct. 1976**

R. H. Miller, M. Martinez-Sanchez, J. Dugundji, E. E. Larrabee, I. Chopra, T. Humes, S. Y. Chung, J. C. Gohard, and J. T. Edwards Oct. 1976 431 p refs Sponsored in part by ERDA

(Grant NSF AER-75-00828)

(PB-268718/4; ASRL-TR-184-3; NSF/RA-760569;

ERDA/NSF-00826-75/3) Avail: NTIS HC A19/MF A01 CSCL 10B

Various problems associated with the design of horizontal axis, low solidity, and high performance wind turbines are investigated. Wind turbine performance as determined from various elementary and more refined momentum theories, aerodynamic vortex theories for blade loadings including unsteady effects and wind shear velocity gradients, and nonlinear dynamic response of rotor blades including gravity and wind shear excitation were studied. GRA

**BEHAVIOR OF WIND DRIVEN SYNCHRONOUS GENERATORS UNDER WIND GUSTS.**

This paper presents the results of a computer simulation conducted for an aeroturbine-drive synchronous generator operating in parallel with a large utility grid. Coupled nonlinear differential equations describing the dynamic behavior of such a system are solved numerically by employing fourth order Runge-Kutta technique. The simulation takes into account instantaneous variations in the coefficient of performance of the aeroturbine due to changes in the tip speed to wind speed ratio. Influence of parameters such as system inertia, damping coefficient, external reactance, machine reactance and generator excitation are examined under conditions of short and long duration wind gusts by simulating a generator torque angle  $\delta$  as a function of time. 15 refs.

Qazi, A.Q. (Oklahoma State Univ., Sch. of Electr. Eng., Stillwater); Ramakumar, R. *Control of Power Syst Conf & Expo. Conf Rec. Tex A&M Univ., College Station, Mar 14-16 1977* Publ by IEEE (Cat n 77CH1168-4REG5), New York, NY, 1977 p 20-25.

**N77-23613#** Defence Research Establishment Ottawa (Ontario). **A COMPUTER PROGRAM TO CALCULATE AND PLOT WIND-GENERATED STORED ENERGY AT CONSTANT CONSUMPTION**

E. M. L. Valerote Jun. 1976 46 p

(AD-A029977; DREO-TN-76-15)

Avail: NTIS

HC A03/MF A01 CSCL 09/2

A computer program has been described which gives printed and plotted outputs of the quantity of wind-generated energy remaining in a storage system under given conditions. The program permits simulated variations of storage capacity, constant electrical load and conversion efficiency by simple data changes. Further alterations to the program itself are detailed, to adapt it to carry out similar calculations for wind turbines of various sizes of construction. The program has been tested by simulation of a hypothetical system of energy production, storage and consumption. It is planned that its predictions will be compared with data obtained from an experimental program currently in progress. Author (GRA)

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1976  
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Agriculture, biomass, wind, new developments  
: joint conference, American Section,  
International Solar Energy Society and  
Solar Energy Society of Canada, inc.,  
August 15-20, 1976, Winnipeg / editor, K.  
W. Boer. — Cape Canaveral, Fla. : American  
Section of the International Solar Energy  
Society, c1976.

# WIND

PRELIMINARY ASSESSMENT OF THE POTENTIAL FOR MEDIUM AND LARGE CAPACITY WIND GENE- RATORS USED AS FUEL SAVERS FOR AC DIESEL BASED POWER SYSTEMS IN ONTARIO	180
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WIND ENERGY STATISTICS FOR  
LARGE ARRAYS OF WIND TURBINES (NEW  
ENGLAND AND CENTRAL U.S. REGIONS). The  
performance characteristics are simulated for large  
dispersed arrays of 500 kW-1500 kW wind turbines  
producing power and feeding it directly into the New  
England or Central U.S. utility distribution grids. These  
studies show that in good wind environments the 500  
kW generators can average (on an annual basis) up to  
240 kW mean power output, and the 1500 kW genera-  
tors can average up to 350 kW mean power output.  
Better performance (averaging up to 470 kW) is ob-  
tained, however, by an 1125 kW rated power unit  
designed to operate at lower wind speeds. The beneficial  
effect of operating large disperse arrays of wind turbines  
is that available power output can be increased—if  
winds are not blowing over one part of the array.

chances are they will over some other part of the array.  
These studies indicate that wind power availability  
levels of 200 kW per 1125 kW generator were 77% to  
93%, depending on season. 4 refs.

Justus, C.G. (Ga Inst of Technol, Atlanta). *Sharing the  
Sun; Sol Technol in the Seventies, Pt 1 Conf of the Int Sol  
Energy Soc; Am Sect and Sol Energy Soc of Can, Inc.  
Winnipeg, Mannt, Aug 15-20 1976 Publ by Int Sol  
Energy Soc, Am Sect, Cape Canaveral, Fla, 1976 v 7 p  
268-288*

## An economic evaluation of small-scale wind powered electric generation systems.

Obermeier, J. L. and Townes, H. W. (Montana  
State Univ., U.S.A.). New York, ASME, 1976,  
4pp. (ASME Paper 76-WA/Ener-1).

Presented is an economic evaluation of  
several commercial wind powered electric  
generation systems of the type which could be  
used by an individual home owner. A system  
includes a wind plant, tower, storage battery  
and d-c to a-c inverter. The analysis consid-  
ered a total of 12 different system configurations  
The evaluation of energy output was based on  
wind speed data for several locations in the  
state of Montana. The analysis can be extended  
to other locations on the basis of mean annual  
wind speed. The results of the evaluation in-  
dicate that some of the home built systems are  
competitive economically at the present time in  
some windy locations. None of the systems  
which are economic could individually supply  
the entire power requirement for a single  
family dwelling. (A).

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226 pages, hardbound (© 1976) .....\$12.95

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1976

A78 22226 International Symposium on Wind Energy Systems, St. John's College, Cambridge, England, September 7-9, 1976. Proceedings. Symposium sponsored by the British Hydro-mechanics Research Association. Edited by H. S. Stephens, M. P. Patel, and N. G. Coles. Cranfield, Beds., England, British Hydro-mechanics Research Association, 1977. 482 p. \$36.50. (For individual items see A78-22227 to A78-22251)

Aspects of large scale wind energy conversion system design and installation as affected by site wind energy characteristics, grouping arrangement, and social acceptance are considered along with the potential for power production by large dispersed arrays of wind turbines, the mathematical modeling of topographic effects on wind energy systems, computer-aided aerogenerator analysis and performance, a study on the use of windmills in Singapore, wind tunnel simulation of the influence of two dimensional ridges on wind speed and turbulence, and performance-optimized horizontal axis wind turbines. Attention is also given to a crossflow wind turbine, a wind energy conversion system based on the tracked vehicle airfoil concept, design aspects of high-speed vertical-axis wind turbines, a performance prediction model for the Darrieus turbine, aerodynamic studies on a vertical axis wind turbine, a variable geometry vertical axis windmill, a low cost windmill rotor, windmills with diffuser effect induced by small tipvanes, a self-contained 5000 kW capacity wind energy conversion system with storage, and underground gas storage in the U.S. and its potential application to wind-powered systems.

G.R.

HD Tarver, Stephen

9502

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1976

A simple solution to the energy problem / by Stephen Tarver. -- 3d ed. -- Gillette, Wyo. : Wyoming Specialties, Inc., c1976. 91 p. : map ; 23 cm.

1. Power resources. 2. Wind power. 3. Energy policy. I. Title.

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Wind energy bibliography. Mukwonago, Wisconsin, Windworks, 1974. 1 v. (unpaged) 23 cm. Cover title.

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## VERTICAL-AXIS WINDMILLS

Aeroelastic Equations of Motion of a Darrieus Vertical  
Axis Wind-Turbine Blade  
by K.R.V. Kaza & R.G. Kvaternik

Dept. of Energy Report DOE/NASA/1028-79/25  
also NASA TM-79295  
December 1979

The second-degree nonlinear aeroelastic equations of motion for a slender, flexible, nonuniform, Darrieus vertical-axis wind-turbine blade which is undergoing combined flatwise bending, edge-wise bending, torsion, and extension are developed using Hamilton's principle. The blade aerodynamic loading is obtained from strip theory based on a quasi-steady approximation of two-dimensional incompressible unsteady airfoil theory. The derivation of the equations has its basis in the geometric nonlinear theory of elasticity and the resulting equations are consistent with the small deformation approximation in which the elongations and shears (and hence strains) are negligible compared to unity. These equations are suitable for studying vibrations, both static and dynamic aeroelastic instabilities, and dynamic response. Several possible methods of solution of the equations, which have periodic coefficients, are discussed.

CONCENTRATION AUGMENTATION OF POWER IN A SAVONIUS-  
TYPE WIND ROTOR  
S. Sivasegaram

Wind Engineering, vol. 3, no. 1, 1979, pp. 52-61.

*The power output of wind turbines is restricted by the diffuse nature of wind energy. Several methods are available for augmenting the power output of horizontal-axis wind turbines, but these methods are not suitable for use with vertical axis wind turbines. The possibility of using concentrators to augment the power output of a Savonius rotor has already been demonstrated. This paper reports a detailed experimental investigation, based on model tests, for determining the optimum design parameters of a concentrator augmentation system and discusses the influence of the geometric parameters of a symmetrical, straight-walled concentrator on the performance of a Savonius-type wind rotor.*

N80 16541# Sandia Labs., Albuquerque, N. Mex.  
ECONOMIC ANALYSIS OF DARRIEUS VERTICAL AXIS  
WIND TURBINE SYSTEMS FOR THE GENERATION OF  
UTILITY GRID ELECTRICAL POWER. VOLUME 3: POINT  
DESIGNS

R. D. Grover and E. G. Kadlec Aug 1979 99 p refs 4 Vol  
(Contract EY-76 C-04-0789)  
(SAND 78-0962 Vol-3) Avail NTIS HC A05/MF A01

Features of the Darrieus vertical axis wind turbine design including the blades, the speed increaser, guy cables and cable anchors, transmission, clutch, brakes, and the electrical system are discussed. System weight characteristics are tabulated. The operation and maintenance costs, and requirements reported and detailed descriptions of point designs for 120, 200, 500, and 1600 kW Darrieus vertical axis wind energy system are examined. DOE

N80 16542# Sandia Labs., Albuquerque, N. Mex.  
ECONOMIC ANALYSIS OF DARRIEUS AXIS WIND  
TURBINE SYSTEMS FOR THE GENERATION OF UTILITY  
GRID ELECTRICAL POWER. VOLUME 4: SUMMARY AND  
ANALYSIS OF THE A. T. KEARNEY AND ALCOA LABORA-  
TORIES POINT DESIGN ECONOMIC STUDIES

W. N. Sullivan Aug 1979 250 p refs 4 Vol  
(Contract EY-76 C-04-0789)  
(SAND 78-0962 Vol-4) Avail NTIS HC A11/MF A01

Two independent economic studies to assess the installed costs of a series six Darrieus vertical axis wind turbine designs are summarized. The designs cover a range of sizes with peak outputs from 10 to 1600 kW. And are designed produce utility grid electrical power. A comparison and analysis of the studies is presented. DOE

A79 51776 Operation and analysis of a vertical axis wind turbine. S. J. Wake (Lockheed Missiles and Space Co., Inc., Sunnyvale, Calif.), H. R. Braun (Defence Research Establishment, Ottawa, Canada), and D. J. Bristow (Canadian Forces, Borden, Ontario, Canada). In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1. (A79 51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 303-307, 5 refs.

A 15 prototype Vertical Axis Wind Turbine (VAWT) located at the Defence Research Establishment Ottawa (DREO) has been monitored for three years. The turbine is used in combination with storage batteries to drive a continuous 60 W load. This system, the failures and modifications, are described. A computer simulation of the VAWT/battery storage system is discussed in relation to actual DREO site data. As an example, temperature and wind data from a weather station at Alert Northwest Territories are used to illustrate how the program might be utilized to assess the suitability of the system in another location. (Author)

# COMPARATIVE PERFORMANCE MEASUREMENTS ON A SAVONIUS ROTOR WITH ANCILLARY SURFACES.

D. V. Nguyen

Wind Engineering, vol. 3, no. 2, 1979, pp. 115-120.

*In an attempt to improve the performance of the conventional Savonius rotor, a model rotor was fitted with ancillary surfaces of aerofoil and 'umbrella' form to produce six alternative configurations.*

*Wind tunnel tests on the models showed the performance to be improved in only one case; in the other units tested the drag effect of the ancillary surfaces appeared to predominate over any possible flow improvement.*

A79-46528 # Economic overview of vertical axis wind turbines. W. N. Sullivan (Sandia Laboratories, Albuquerque, N. Mex.). In: Workshop on Economic and Operational Requirements and Status of Large Scale Wind Systems, Monterey, Calif., March 28-30, 1979, Proceedings. (A79-46526 20-44) Santa Cruz, Calif., Altas Corp., 1979, p. 73-81; Discussion, p. 82. Contract No. AT(29-1)-789.

An economic overview of vertical axis wind turbines (VAWT) is presented. The most favorable systems investigated can provide utility electricity with a cost in the range of 4-6 cents/kWh with existing technology. The cost of energy decreases as VAWT rotor size increases up to the largest system investigated (1600 kW). This is due primarily to the presence of costs which vary slowly or not at all with rotor size. These costs are associated with operation, maintenance, and automatic control hardware. These slow-varying costs dominate the smaller systems and tend to limit their cost-effectiveness. The cost of energy of all size systems is sensitive to the median annual windspeed, while the cost of larger systems is sensitive to the wind exponent. V.T.

A80-21929 Development of vertical axis wind turbines. P. N. Shankar (National Aeronautical Laboratory, Bangalore, India). Indian Academy of Sciences, Proceedings, Section C: Engineering Sciences, vol. C 2, Mar. 1979, p. 49-61, 63-66. 11 refs.

This paper summarizes the development of vertical axis wind turbines based on the Darrieus rotor. A performance analysis was developed which permits the estimation of the characteristics of such machines; 5 m high wind turbine using curved wooden blades was fabricated and tested. The tests confirmed the low starting torque of the turbine and wind tunnel tests were performed on model Savonius rotors to determine optimum starter bucket configurations. Finally, a straight-bladed turbine was constructed, concluding that Darrieus turbines should be useful in large systems used to generate electrical power for the grid; for direct water pumping purposes, however, these turbines are unlikely to be suitable. (Author)

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Intersociety Energy Conversion Engineering Conference, 14th, Boston, 1979.

Proceedings of the 14th Intersociety Energy Conversion Engineering Conference, Boston, Massachusetts, August 5-10, 1979. -- Washington, D. C. : American Chemical Society, c1979.

799068  
Operation and Analysis of a Vertical Axis Wind Turbine, S.J. Wake, H.R. Braun and D.J. Bristow ..... 303

A 15' prototype Vertical Axis Wind Turbine (VAWT) located at the Defence Research Establishment Ottawa (DREO) has been monitored for three years. The turbine is used in combination with storage batteries to drive a continuous 60 W load. This system is described, as are the failures and modifications. A computer simulation of the VAWT/battery storage system is discussed in relation to actual DREO site data. By way of example, temperature and wind data from a weather station at Alert Northwest Territories are used to illustrate how the program might be utilized to assess the suitability of the system in another location.

AGARDograph No. 243

Advisory Group for Aerospace Research and Development, NATO

FLUID DYNAMIC ASPECTS OF WIND ENERGY CONVERSION

by O. de Vries

Published July 1979

150 pages

A review is made of the fluid dynamic aspects of wind energy conversion. A short survey of the total framework of wind energy conversion is given to bring the fluid dynamics aspect in its proper dimensions. Next, the several wind concentrator concepts are discussed, while the main body of the report is formed by a discussion of the theory of wind-driven turbines, including both the horizontal-axis and the vertical-axis turbines.

AGARD-AG-243

1979

Fluid dynamics  
Wind power generation  
Windmills  
Wind (meteorology)  
Turbines  
Turbulence  
Wakes



**N80-13675#** Power Technologies, Inc., Schenectady, N. Y.  
**INDUCTION AND SYNCHRONOUS MACHINES FOR  
 VERTICAL AXIS WIND TURBINES** Final Report  
 E. N. Hinrichsen Jun 1979 123 p refs  
 (Contract EY-76-C-04-0789)  
 (SAND-79-7017) Avail. NTIS HC A06/MF A01

The behavior of synchronous and induction generators driven by vertical axis wind turbines is described. The merits of the two types of machines are assessed. Major advantages of the synchronous generator are reactive power control and general acceptance by utility companies. The major advantage of the induction generator is excellent damping of torque pulsations. There is no significant difference in starting ability, efficiency, or voltage ripple. DOE

**A80-11645 #** The pedal wind turbine. T. Vinayagalingam  
 (West Indies, University, St. Augustine, Trinidad and Tobago).  
*Journal of Energy*, vol. 3, July-Aug. 1979, p. 254-256.

A vertical-axis, resistance-type turbine has been developed for wind energy utilization in developing nations. The device employs cycling of the rectangular turbine sail at different orientations to the wind to ensure smooth operation, and resembles a bicycle pedal. Theoretical analysis of the quasi-steady performance of the turbine indicates that a two-sail version of the pedal turbine will exhibit more uniform torque characteristics than the two-bucket Savonius rotor, thus reducing the stalling problem, and will have a peak power coefficient of 0.13. Higher efficiencies are anticipated with a slack sail which assumes a bucket shape under wind pressure, and wind-tunnel tests of a scale model are in progress. A.L.W.

**N79-27670#** Sandia Labs., Albuquerque, N. Mex. Advanced Energy Projects Div.  
**AERODYNAMIC PERFORMANCE OF THE 17-METRE-  
 DIAMETER DARRIEUS WIND TURBINE**  
 M. H. Worstell Jan. 1979 60 p refs  
 (Contract EY-76-C-04-0789)  
 (SAND-78-1737) Avail. NTIS HC A04/MF A01

A two-bladed 17-meter Darrieus vertical-axis wind turbine was field-tested at the Sandia Laboratories wind turbine site. Performance results for seven constant operating speeds are presented along with a discussion of the trends. Predicted performance and experimental test data for two constant speeds are compared. DOE

**N79-32731#** National Aerospace Lab., Amsterdam (Netherlands).  
 Div. of Fluid Dynamics.  
**INVESTIGATIONS ON THE AEROELASTIC STABILITY OF  
 LARGE WIND TURBINES**  
 H. H. Ottens and R. J. Zwaan 10 Apr. 1978 21 p refs  
 Presented at the 2d Intern. Symp. on Wind Energy Sys.,  
 Amsterdam, 3-5 Oct. 1978  
 (NPL-MP-78014-U) Avail. NTIS HC A02/MF A01

The aeroelastic stability of wind turbines with vertical axis (VAWT) and with horizontal axis (HAWT) is discussed. Results are given for an existing 5 m VAWT test-bed with and without a tie-down system. Finally, difficulties are discussed in interpreting preliminary results for a horizontal axis wind turbine. Stability diagrams are shown. Author (ESA)

**EXPERIMENTAL INVESTIGATION OF A CLASS OF  
 RESISTANCE-TYPE, DIRECTION-INDEPENDENT WIND  
 TURBINES.** Sivasegaram, S. (Univ. of Sri  
 Lanka, Peradeniya). *Energy* (Stamford, Conn.):  
 3: No. 1, 23-30 (Feb 1978).

The resistance-type, direction-independent wind turbine is suitable for the generation of power on a small scale in developing countries. So far, all work on this class of wind turbine seems to be restricted to the Savonius rotor. The findings of an experimental investigation of an entire class of wind turbines which includes the conventional Savonius rotor are presented. The influence of four rotor-geometry parameters (i.e., number of blades, blade angle, blade location and angle of setting of the blade) is studied and discussed on the basis of two performance criteria (i.e., turbine efficiency and performance on the basis of blade area). The existence of optimum design parameters is established and the possibility of improving substantially on the performance of the Savonius rotor is demonstrated. Some possible applications of the present class of turbines are briefly commented on.

**A79-15882** Utility applications of wind power plants. W. D. Marsh (General Electric Co., Electric Utility Systems Engineering Dept., Schenectady, N.Y.). In: *Energy technology V: Challenges to technology; Proceedings of the Fifth Conference*, Washington, D.C., February 27-March 1, 1978. (A79-15879 04-44) Washington, D.C., Government Institutes, Inc., 1978, p. 83-96. Research supported by the Electric Power Research Institute.

The paper describes the procedures and preliminary results of a study being performed for the Electric Power Research Institute under Project RP-740-1, 'Requirements Assessment of Wind Energy Systems'. Three areas have been selected for this study: Western Kansas, Northern New York, and Western Oregon. It is shown that conventional electric utility planning methods can be successfully adapted to the study of wind power plants. While significant capacity credit can be calculated using probability methods, it is yet to be determined if in actual practice such firm capacity will be granted wind power plants. Although no study has yet been made of alternate utility characteristics or of wind power design characteristics, it is certain that these are major factors in the impact of wind power plants on utility systems. There is little reason to believe that the addition of dedicated storage to a wind power plant improves its economic viability. B.J.

# AERODYNAMIC CHARACTERISTIC OF A CYLINDRICAL TYPE OF WIND TURBINE WITH INCLINED BLADES

B. H. L. Gowda and N. V. Swamy

J. Energy., vol.2, no.2, March-April 1978, p122-124

**T**HERE are basically two types of wind turbines, the horizontal-axis type and the vertical-axis type, depending on the axis about which the blades rotate. In recent times the Darrieus type of wind turbine, which belongs to the second category, has been investigated both theoretically and experimentally by a number of investigators.<sup>1,6</sup> Recently, Blackwell et al.<sup>7</sup> have described the engineering development of Darrieus turbines with particular emphasis on the influence of aerodynamic, structural, and system considerations on energy costs. This type of machine has blades bent to the shape of a catenary, and the construction of such blades is quite involved and costly. It is found that a large percentage of the total torque (about 80%) is contributed by the central 60-70% of the blades, which is nearly vertical.<sup>8</sup> This has been taken into account in the design and development of a "cylindrical" type of vertical-axis machine, and its detailed aerodynamic characteristics have been described by Gowda and Swamy.<sup>9</sup> In this type, the parabolic shape (or catenary shape) is dispensed with and the blades are made vertical, making their construction much simpler. Shanker<sup>5</sup> has also, very briefly, referred to such a type of wind turbine. But it is inconvenient to support such a windmill with guy wires, for obvious reasons. This inconvenience would be overcome if the straight blades are provided with inclined portions at their top and bottom ends (as in Fig. 1). The aerodynamic characteristics of such a windmill are described in this note.

A79 38656

Design analysis of a vertical axis wind turbine.

L. F. Jesch and D. Walton (Birmingham, University, Birmingham, England). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports, Volume 3. (A79 38576 16-44) Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 157-168. 9 refs.

Aerodynamic and structural design analysis of a Darrieus rotor is presented. The computer model uses published experimental data for the NACA 0012 aerofoil. The analysis of the relative contributions of the troposkien blade elements leads to a suggested cutting off parts of the blade which widens the useful velocity range. The effects of blade numbers on performance and stresses are analyzed. (Author)

# PERFORMANCE OF COUNTER-AND COROTATING ARRAYS OF SAVONIUS TURBINES

A. F. Charwat

J. of Energy

Vol. 2 no. 1 January-February 1978

p. 61-63 The experiments described in this paper were conducted to explore the effects of the mutual interaction between two closely spaced corotating and counterrotating Savonius rotors. Also, a row of rotors spaced over the entire cross-section of the tunnel was tested. (It can also be viewed as an infinite row.) Such a configuration can be imagined to represent, for example, a "power extraction" dam across a river. The results suggest that the operation of these rotors in parallel arrays may have practical merit.

SOME COMMENTS ON THE PAPER, "PERFORMANCE CHARACTERISTICS OF CONCENTRATOR - AUGMENTED SAVONIUS WIND ROTORS,"

A. Sabzevari (Wind Engineering Vol.1, No.3, pp 198-206)

Wind Engineering,

Vol. 2, No. 1, 1978, p. 59-60.

The results presented in the above paper illustrate the nature of the influence of concentrators and diffusers on the performance of Savonius rotors. However, certain matters reported in the paper appear to require further clarification and certain others appear to be in conflict with the findings of earlier work.

A79 10239

Torque ripple in a vertical axis wind turbine.

R. C. Reuter, Jr. and M. H. Worstell (Sandia Laboratories, Albuquerque, N. Mex.). In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings, Volume 3. (A79 10001 01-44) Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 2090-2098. 9 refs. Research supported by the U.S. Department of Energy.

Torque ripple is a name given to time variations in torque which are propagated through the drive train of wind energy conversion systems. This paper covers an analytical and experimental investigation of torque ripple in a Darrieus vertical axis wind turbine. An analytical model of the turbine is described and numerical results from a solution to the equations of this model are compared to experimental results obtained from the existing DOE/Sandia 17 meter vertical axis wind turbine. Discussions on the sources of torque ripple, theoretical and experimental correlation, and means of suppressing its magnitude are included. (Author)

A79-17120 # The Netherlands experimental vertical axis wind turbine. J. B. D. H. Bolt (Fokker-VFW, Schiphol Airport, Netherlands). In: Nederlandse Vereniging voor Luchtvaarttechniek, Yearbook 1977. (A79-17117 05-01) Amsterdam, Nederlandse Vereniging voor Luchtvaarttechniek, 1978, p. 5-1 to 5-8.

The paper gives a general description of an experimental 5.3-m-diam vertical axis wind turbine and its associated power conversion system and other subsystems. The two glass-fiber reinforced plastic blades are strengthened by bonded light metal plates. As design criteria for the static strength of the blades, a maximum blade rotation speed of 450 rpm in calm weather conditions and a reducing speed of 2.5 rad/sq sec at 325 rpm are used. The rotor operates in two modes: constant speed, and constant blade-speed/wind speed ratio. Block diagrams of the mechanical-hydraulic energy conversion system and the control and protection systems are presented. The test program will comprise measurement of vibration characteristics of the turbine when stationary and running, with or without tethering, measurement of turbine efficiency at constant rotor rpm and blade-speed/wind speed ratio, measurement of tension in the blade roots, and measurement of the influence of tension in the guy wires on dynamic behavior of the turbine. P.T.H.

## SOME CONTRIBUTIONS TO AERODYNAMIC THEORY FOR VERTICAL AXIS WIND TURBINES

Holt Ashley

J. Energy, Vol. 2, no. 2, March-April 1978, p113-119

**T**his paper describes some attempts to contribute to the aerodynamic theory for Darrieus wind turbines and related vertical-axis wind energy conversion devices. The goal—only partially realized—is to adapt the analysis of thin lifting surfaces under both quasisteady and unsteady flow conditions so as to illuminate the essential features of how these rotary machines operate, while avoiding the need for massive numerical computation. In this spirit, the theories to be presented are intermediate in complexity, and presumably in accuracy, between rough estimates such as those given by Wilson et al.<sup>1</sup> (pp. 89-92) and complicated vortex methods. It is hoped that some of the results may prove useful for purposes of preliminary design.

A79-37895 The aerodynamic design and testing of a vertical axis windmill. A. C. Willmer (British Aerospace, Aircraft Group, Bristol, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 286-289, 9 refs.

Wind tunnel tests were conducted in order to refine a mathematical model for the design of large vertical axis windmills. The mathematical model uses an induced velocity factor derived from the test data. This factor was derived by a relaxation process in which the calculated cross arm and blade loads were made to agree with the measurements by adjusting the induced velocity factor. B.J.

## N79-19446 Massachusetts Univ., Amherst TWO DIMENSIONAL ANALYSIS OF VERTICAL AXIS WINDMILLS Ph.D. Thesis

Edward S. VanDusen 1978 296 p  
Avail. Univ. Microfilms Order No. 7903857

A two dimensional inviscid flow model is developed for vertical axis windmills with two foils of arbitrary shape. The solution is in the reference frame of the rotating foils and includes a time developing wake as vorticity is shed from the trailing edge of each foil. The results from different time steps, hence rotor orientations, are presented as plots of torque, streamlines, and power coefficient over a wide range of tip speed ratios. A heuristic stall model to account for flow separation is included in a manner that anticipates future viscous analysis. Results investigating the time step between solutions and different geometries are presented and compared to empirical values. Dissert. Abstr.

TJ Pierson, Richard E., 1934-  
810 Technician's and experimenter's  
.P53 guide to using sun, wind, and water  
power / Richard E. Pierson. West  
Nyack, N.Y. : Parker Pub. Co., c1973.  
270 p. : ill. ; 24 cm. \$9.95  
Includes index.

## 10. Building the Vertical-Shaft Pierson Wind Turbine - 147

Height and Zoning Restrictions (147) Detailed Description (150)  
Turbine (150) Base Box (158) Walls and Top Support (161) RPM Ratio  
Equipment (163) Generator (166) Safety (173)

## N78-27569# Sandia Labs., Albuquerque, N. Mex. BRAKE SYSTEM FOR THE 17 METER VERTICAL AXIS WIND TURBINE

C. W. Dodd Feb. 1978 27 p  
(Contract EY-76-C-04-0789)  
(SAND-77-1331) Avail. NTIS HC A03/MF A01

The design philosophy and operating procedure of the hydraulic brake system on the 17-meter vertical axis wind turbine are described. Design details and a functional description of system components are included.

ERA

**N78-28631# Sandia Labs., Albuquerque, N. Mex.**  
**MINICOMPUTER BASED DATA ACQUISITION AND**  
**ANALYSIS SYSTEMS FOR VERTICAL AXIS WIND TURBINE**  
**TESTING**

B. Stefeld and R. Tomlinson 1978 10 p. ref. Presented at the 24th Intern. Instrumentation Symp., Albuquerque, N. Mex., 1 May 1978.

(Contract EY 76 C 04 0789)

(SAND-78 0187C. Conf-780503-4)

Avail. NTIS

HC A02/MF A01

The computer based data acquisition system and instrumentation used to acquire environmental, structural, and performance data from the VAWT complex are described. An airborne type PCM encoder mounted on the turbine shaft is used to digitize much of the data, particularly the low level strain information from the turbine blades and supporting structure. The data system is an extension of recently completed work on a similar system for a large, 8.8 meter (29 foot) centrifuge facility. Computer software which provides near real time graphic and analytic capabilities is also described.

ERA

**THE INFLUENCE OF BLADE CAMBER ON THE OUTPUT OF VERTICAL-AXIS WIND TURBINES**, by Dr. J. V. Healy.

Wind Engineering, vol. 2, no. 3, 1978, p. 146-155.

*This study represents an extension to cambered airfoils of a previous work on symmetric ones. The model used is the multiple-streamtube one and the airfoils have Gottingen profiles - the only ones for which sufficient data is available. It is found that airfoils with high lift can abstract more than the optimum amount of energy from each streamtube. This high lift can be generated by using camber or by presetting symmetric profiles at some initial angle of incidence. In general, the closer the airfoil is to symmetric, the more satisfactory its power output. Cambering or presetting the angle of incidence seems a likely way to avoid excessive turbine speeds.*

**A79-33265 # Mechanical and vibrational problems of a vertical axis wind turbine.** W. B. H. Cooke, M. E. Weekes (Saskatchewan Power Research Centre, Regina, Canada), and P. J. Catania (Paralha, Universidade Federal, João Pessoa, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings, Volume C. (A79-33212 13-44) Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 994-1002.

This paper reports on the mechanical and vibrational difficulties encountered with the operation of a prototype 4.57 m vertical axis wind turbine during the period of 1976-1977 at Regina, Saskatchewan, Canada. The work on evaluating this unit has highlighted some of the difficulties, and the second generation units should prove to be more satisfactory.

(Author)

**THE LEBOST WIND TURBINE: LABORATORY TESTS AND DATA ANALYSIS.**

Martin I. Hoffert, Gregory L. Matloff, &

Barry A. Rugg

Journal of Energy, Vol. 2, No. 3, May/June 1978, p. 175-181.

In

this paper we present preliminary results from a series of wind tunnel tests assessing the aerodynamic torque and power characteristics of the Leboist Wind Turbine. Although this innovative wind energy conversion machine is at an early stage of its development cycle, the results of this initial laboratory test phase appear sufficiently encouraging to warrant publication at this time.

(SAND--78-0397C) VERTICAL AXIS WIND TURBINE STATUS. Bransch, C.H.; Brandvold, G.E. (Sandia Labs., Albuquerque, N.Mex. (USA)). 1978. Contract EY-76-C-04-0789. 12p. (CONF-780114--4). Dep. NTIS, MF A01. From International Solar Energy Congress; New Delhi, India (16 Jan 1978). Portions of document are illegible. Research and development activities on the Darriens wind turbine at Sandia Laboratories are described.

**WIND TUNNEL PERFORMANCE DATA FOR TWO - AND THREE - BUCKET SAVONIUS ROTORS.**

Robert E. Sheldahl, Bennie F. Blackwell, & Louis V. Feltz

Journal of Energy, Vol. 2, No. 3, May/June 1978, p. 160-164.

Fifteen configurations of a Savonius rotor wind turbine were tested in the Vought Corporation Systems Division 4.9 x 6.1-m Low Speed Wind Tunnel to determine aerodynamic performance. The range of values of the varied parameters was as follows: number of buckets, 2 and 3; nominal freestream velocity, 7 and 14 m/s; Reynolds number per meter,  $4.32 \times 10^5$  and  $8.67 \times 10^5$ ; rotor height, 1 and 1.5 m; rotor diameter (nominal), 1 m; bucket overlap, 0.0-0.1 m. The measured test variables were torque, rotational speed, and tunnel conditions. It is concluded that increasing Reynolds number and/or aspect ratio improves performance. The recommended configuration consists of two sets of two-bucket rotors, rotated 90 deg apart, with each rotor having a dimensionless gap width of 0.1-0.15.



## THE DESIGN AND TESTING OF A VERTICAL-AXIS WIND TURBINE USING SAILS

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*Energy Conversion*, Vol. 18, pp. 141-154  
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**Abstract** A vertical-axis wind turbine using sails rather than solid blades has been designed and tested at large model scale in a 15 ft diameter wind tunnel. The turbine has a relatively high solidity, three blades and an operating range of tip speed ratios from zero to about 2.5. Two types of sail have been tested: a double sail consisting of two layers of cloth wrapped round a circular leading edge dowel, and a jib sail consisting of a single layer of cloth with the leading edge held by a taut wire. The measured power outputs are about half those of a turbine with solid aerofoil blades running at tip speed ratios of 5 or 6. However, the cost and skill required for manufacture of the sail turbines are less and it is concluded that the present designs, which can be self starting if the trailing edge tension is appropriately set, may have application for 1 kW machines in developing countries.

Sail wind turbine Wind turbine Windmill Darrieus wind turbine Vertical-axis wind turbine Sail wing Jib sail Solar energy Appropriate technology Third-world technology

## NASA CP-2034

**WIND TURBINE STRUCTURAL DYNAMICS.** Dean R. Miller, LeRC, ed. (Workshop sponsored by DOE and held LeRC, Nov. 15-17, 1977). Mar. 1978. 299p.

(CONF-771148—, pp. 39-52) Use of asymptotic methods in vibration analysis. Ashley, H. (Stanford Univ., CA) 1978.

From Wind turbine structural dynamics conference; Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

Two subjects are discussed, which are believed relevant to the structural analysis of vertical-axis wind turbines. The first involves the derivation of dynamic differential equations, suitable for studying the vibrations of rotating, curved, slender structures. The Hamiltonian procedure is advocated for this purpose. Various reductions of the full system are displayed, which govern the vibrating Troposkien when various order-of-magnitude restrictions are placed on important parameters. The final section discusses the possible advantages of the WKB asymptotic method for solving these classes of problems. A special case of this method is used illustratively to calculate eigenvalues and eigenfunctions for a 'flat' turbine blade with small flexural stiffness.

## NASA CP-2034

**WIND TURBINE STRUCTURAL DYNAMICS.** Dean R. Miller, LeRC, ed. (Workshop sponsored by DOE and held LeRC, Nov. 15-17, 1977). Mar. 1978. 299p.

(CONF-771148—, pp. 77-93) Flutter of Darrieus wind turbine blades. Ham, N.D. (Massachusetts Inst. of Tech., Cambridge) 1978.

From Wind turbine structural dynamics conference; Cleveland, OH, USA (15 Nov 1977).

In Wind turbine structural dynamics.

The testing of Darrieus wind turbines has indicated that under certain conditions, serious vibrations of the blades can occur, involving flatwise bending, torsion, and chordwise bending. A theoretical method of predicting the aeroelastic stability of the coupled bending and torsional motion of such blades is presented with a view to determining the cause of these vibrations and a means of suppressing them.

**N80 12579#** Sandia Labs. Albuquerque, N. Mex. Div. 4715. **EFFORTS ON THE ECONOMIC ANALYSIS OF DARRIEUS VERTICAL AXIS WIND TURBINES**

W. N. Sullivan. 1978. 8 p. ref. Presented at Am. Wind Energy Assoc. Conf., Hyannis, Mass., 25 Sep. 1978.

<sup>2</sup> (Contract EY-76-C-04-0789)

(SAND-78-1851C, CONF-780972-1) Avail. NTIS HC A02/MF A01

There is an ongoing program designed to establish reasonable estimates for the cost of utility grid energy produced by Darrieus VAWT systems. The economic analysis is based on the detailed examination of actual point designs, which cover a range of system sizes. The approach is unique in that in addition to determining the direct costs of system components, an effort is made to include the indirect costs and profits of the manufacturing, marketing, distributions, and sales tasks of the enterprise producing the systems. The point design specifications and drawings were developed and provide the baseline for this study. The specifications represent optimum designs, as determined by an economic optimization model. This model, with mathematical formulas for the costs of major system elements, was used to select from many possibilities an optimum set of design specifications.

DOE

**WIND TUNNEL TESTS ON A SAVONIUS ROTOR.**

A.J. Alexander and B.P. Holownia.

*Industrial Aerodynamics*, v.3, 1978, p.343-51.

Tests have been made in a wind tunnel on a number of Savonius rotor configurations in wind speeds of 6-9 m/s. The variables tested were blade aspect ratio, blade overlap and gap and the effects of adding end extensions, end plates and shielding.

For low aspect ratios (~1) with no additions the efficiency was low (~0.065) but for higher aspect ratios (~5) with optimum blade configuration and shielding a maximum value of efficiency of 0.25 was obtained. Tests with three and four bladed configurations gave appreciably lower values of efficiency.

A special study was made of wind tunnel corrections for blockage ratios up to 0.3.



A79-14291 A low cost blade design for a Darrieus-type vertical axis wind turbine. D. K. Ai (Alcoa Research Laboratories, Pittsburgh, Pa.). *Wind Technology Journal*, vol. 2, Spring-Summer 1978, p. 18-23, 13 refs.

A brief description of the Darrieus-type vertical axis wind turbine (VAWT) is given, followed by a short history of its development. Blade characteristics for the Sandia 5 m and 17 m research turbines are also shown. With the mass-balance condition removed, a low cost blade based on a single piece of aluminum extrusion became feasible. A set of 6 in. chord blades of all airfoil section, is used for Sandia's 5 m research wind turbine. This blade is now commercially available. Other VAWTs using this blade include the 5 m Dynergy machine and the Clarkson College/Alcoa/Agway/Niagara Mohawk machine. Blades of larger chords of a similar design are in the planning. It is expected that an 11 in. chord blade will be used for the DOE 8 kW machine to be installed at Rocky Flats, Colorado, and a 24 in. chord blade for the DOE's low cost 17 m machines. It is believed that within the size limitation of the existing extrusion presses, the all-aluminum single piece extrusion blade represents the most cost effective blade for the Darrieus-type VAWT.

A78-42420 Secondary parameters affecting the performance of resistance-type vertical-axis wind rotors. S. Sivasegaram (University of Sri Lanka, Paradeniya, Sri Lanka). *Wind Engineering*, vol. 2, no. 1, 1978, p. 49-58, 11 refs.

An experimental study of the effect of four parameters - Reynolds number, wake aspect ratio, the size of the end plate, and the shaft diameter - on resistance-type vertical-axis wind rotors is described. The optimum diameter of the end plate is found to be just in excess of the wake width, and the shaft's adverse effect upon performance is found to become significant only when the shaft diameter is relatively large. Design profiles of some resistance-type vertical-axis rotors are shown, and differences in their characteristics are considered. M.L.

A78-49838 Some preliminary results on the performance of a small vertical-axis cylindrical wind turbine. G. Ahmadi (Pahlavi University, Shiraz, Iran). *Wind Engineering*, vol. 2, no. 2, 1978, p. 65-74, 20 refs. Research supported by the Pahlavi University.

The performance of a newly developed small vertical-axis wind turbine with two sail blades is described. The model design is explained, and the effect of wind velocity and various blade angle settings on the power coefficient is studied. Maximum power coefficients for various conditions are plotted. Although the maximum efficiency of the model is only about 7%, it is suggested that the use of this wind energy convertor in remote rural areas of developing countries might be feasible due to the simplicity of the blade design and the relatively low cost of construction. M.L.

## AN INVERSE PROBLEM FOR VERTICAL-AXIS WIND TURBINES, by J. V. Healy.

*Journal of Energy*, vol. 2, no. 6, Nov.-Dec. 1978, p. 382-384.

**T**HE conclusion that the maximum theoretical power coefficient for wind turbines is  $16/27 = .59$  and that the wake velocity is  $1/3 V$  was reached by Betz<sup>1</sup> about 1920.

The multiple-streamtube model<sup>2,4</sup> involves dividing the flow through the turbine into tubes. A balance between the force on the blades, obtained from blade element theory, and the rate of change of momentum of the fluid in the tube, assuming actuator-disc theory, gives an equation which is solved for the inflow factor  $A$  by iteration. When  $A$  is found, the power coefficient is obtained by using blade element theory. This latter step involves the energy equation. The power coefficient is averaged for each streamtube to give an overall value. Thus the momentum and energy equations, which form an independent set, are used to obtain  $A$  and  $C_p$ .

While studying the direct problem for the influences of blade thickness and camber<sup>4,5</sup> the author became aware that profiles possessing very high lift were undesirable, as they abstracted more than the optimum amount of energy from the wind. This raised the question of the nature of the most desirable lift and drag forces. The solution is obtained quite simply by specifying  $A = 1/3$ ,  $C_p = 16/27$ , and solving for the lift and drag coefficients and the corresponding value of the angle of attack.

A78-49839 Model and prototype performance characteristics of Savonius rotor windmill. M. H. Khan (Illinois, University, Urbana, Ill.). *Wind Engineering*, vol. 2, no. 2, 1978, p. 75-85, 7 refs. Research supported by the Ford Foundation.

Model tests were conducted in a wind tunnel to arrive at an optimum configuration of Savonius rotor windmill. Effects of three design parameters, namely rotor shape, overlap between rotor blades, and separation gap between rotor blades, on the operating characteristics were studied. Rotor models with different combinations of the variable parameters were tested under three wind velocities to determine the configuration which would provide the best relative performance. From this study it was found that the optimum configuration was different from the standard Savonius design not only in the blade shape but also in the overlap distance between blades. On the basis of the results obtained from model tests, a prototype unit based on the optimum design configuration was built and tested on an open site. Results obtained from the tests of the full scale design are encouraging. The results have corroborated some of the original findings of Savonius. (Author)

**A79-40125** Development of the Variable Geometry Vertical Axis Windmill. P. J. Musgrove and I. D. Mays (Reading, University, Reading, England). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. (A79-40101 17-44) Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. E4-39 to E4-60. 21 refs. Science Research Council Grant No. 8/RG/92338.

The simplicity of the Variable Geometry Vertical Axis Windmill (VGVAW) makes it attractive for many applications, large scale and small. This paper concentrates on measurements that have been made on a 3-m-diam VGVAW prototype. Work on large-scale versions of the design is proceeding separately in collaboration with industry. The performance of the 3-m low-solidity prototype has been measured in the open air, and a peak power coefficient of 0.30 to 0.35 recorded. This is in reasonable agreement with theoretical predictions and compares favorably with available open-air test data for Darrieus and horizontal-axis windmills. The choice of optimum solidity is discussed in some detail, and the effects of low aspect ratio considered. It is shown that low aspect ratio combined with high solidity can be expected to give aerodynamic self-start with only minor loss of performance. A low-aspect-ratio high-solidity vertical-axis windmill was therefore also constructed, and these expectations confirmed. (Author)

**A79-40124** The design, construction, testing and manufacturing of vertical axis wind turbines. R. H. Braasch (Sandia Laboratories, Albuquerque, N. Mex.). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. (A79-40101 17-44) Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. E3-23 to E3-38. 10 refs. Research supported by the U.S. Department of Energy.

The design, construction and testing of a 17-meter Darrieus type vertical axis wind turbine (VAWT) are described, and results of a performance-cost optimization study and manufacturing studies of VAWTs are presented. Two- and three-blade rotor configurations have been tested. The blades are troposkein-shaped, with a symmetrical airfoil cross section developed from helicopter-blade technology. The power train has 13 gear-ratio settings and both induction and synchronous electrical power generation are possible. Results of tests measuring performance parameters, blade operating stress levels, fatigue life, and machine torque ripple are presented. Estimated energy cost trends versus machine diameter and rated machine output power are reported, together with expected torque, power, and weight, for VAWTs of different sizes. The basic design considered incorporates extruded aluminum blades, large diameter/low weight spiral wrapped and welded steel towers, a two-bladed rotor, a height-to-diameter ratio of 1.5, a stiff cable support system, and a differential for synchronous motor starting or reduced voltage starter for induction motor starting. Point designs of 200 KWe, 500 KWe, and 1600 KWe were analyzed. C.K.D.

THE INFLUENCE OF BLADE CAMBER ON THE OUTPUT OF VERTICAL-AXIS WIND TURBINES, by Dr. J. V. Healy. Wind Engineering, vol. 2, no. 3, 1978, p. 146-155.

*This study represents an extension to cambered airfoils of a previous work on symmetric ones. The model used is the multiple-streamtube one and the airfoils have Gottingen profiles - the only ones for which sufficient data is available. It is found that airfoils with high lift can abstract more than the optimum amount of energy from each streamtube. This high lift can be generated by using camber or by presetting symmetric profiles at some initial angle of incidence. In general, the closer the airfoil is to symmetric, the more satisfactory its power output. Cambering or presetting the angle of incidence seems a likely way to avoid excessive turbine speeds.*

THE INFLUENCE OF BLADE THICKNESS ON THE OUTPUT OF VERTICAL AXIS WIND TURBINES.

J.V. Healy.

Dept. of Engineering Mathematics, The Queen's University of Belfast, Ashby Institute, Belfast BT9 5AH.

Wind Engineering. 1978, Vol.2, 1, 1-9.

The amount of data required to compute the output of straight-blade turbines is only a fraction of what is needed for curved-blade ones. Using the data in NACA TR 586, the power coefficients for NACA profiles 0009, 0012, 0015 and 0018 have been computed for a wide range of turbine Reynolds numbers and tip speed ratios from 2.25 upwards. Lift and drag matrices are set up from the data and a standard subroutine used to interpolate for the lift and drag coefficients for given values of angle of attack and blade Reynolds number. The computer program is based on the multiple-stream tube model and takes inflow into account. The results show that the maximum power coefficient is about 0.5, at the highest turbine Reynolds number used ( $2 \times 10^6$ ), and is roughly the same for all profiles. This maximum occurs at a solidity of about .27 and a tip speed ratio around 3. For turbine Reynolds numbers less than  $2 \times 10^6$ , the 0009 profile is inferior to the others. In general, thicker profiles are better at low turbine Reynolds numbers. To assess the influence of reduced drag, computations were made for the 0012 profile with a 50% reduced drag and its measured lift values. The results showed about an 8% increase in the maximum power coefficient.

**N78-28632#** Sandia Labs., Albuquerque, N. Mex. Advanced Energy Projects.

**PRELIMINARY BLADE STRAIN GAGE DATA ON THE SANDIA 17-METER VERTICAL-AXIS WIND TURBINE**

W. N. Sullivan Dec 1977 20 p refs

(Contract EY-76-C-04-0789)

(SAND-77-1176) Avail: NTIS HC A02/MF A01

Results are summarized from blade strain measurements made during the initial operating period of 17 M turbine. The measurements indicate that the blade structure is performing adequately without any apparent fatigue life consumption or excessive vibration. The test results cover a range of turbine speeds (from 29.6 to 59.3 RPM) and wind speeds (from negligible to 50 MPH). ERA

**A78-22236** General performance theory for crosswind axis turbines. P. B. S. Lissaman (AeroVironment, Inc., Pasadena, Calif.). In: International Symposium on Wind Energy Systems, Cambridge, England, September 7-9, 1976, Proceedings. (A78-22226 07-44) Cranfield, Beds., England, British Hydromechanics Research Association, 1977, p. C2-21 to C2-38. 6 refs. NSF Grants No. G1-41840, No. AER-74-04014 A03.

An analytical theory is presented for the determination of the performance characteristics of rotary crosswind axis machines. The considered approach can be used for the preliminary design of wind turbine geometry and the selection of blade sections. It is found that for high chordal ratio (C) devices the crosswind force has a significant adverse effect on power extraction as well as on aerodynamic loads. The theory considers wake induction and unsteady aerodynamics in the simplest way consistent with the objective of developing realistic engineering results. For low C devices this appears to be adequate for a first order analysis, but further refinement is desirable to predict aeroelastic behavior. For high C devices more data is required to validate the proposed viscous corrections. G.R.

**A78-22250** An aerodynamic performance theory for the Darrieus wind turbine. D. J. Sharp (Kingston Polytechnic, Kingston-on-Thames, Surrey, England). In: International Symposium on Wind Energy Systems, Cambridge, England, September 7-9, 1976, Proceedings. (A78-22226 07-44) Cranfield, Beds., England, British Hydromechanics Research Association, 1977, p. X46-X53. 6 refs.

Blade element and momentum theories are used to predict the induced velocity distribution over the vertical height of the Darrieus wind turbine. The effect of local Reynolds number values on airfoil data is also taken into account. The airfoil for the turbine blades is the NACA 0012 profile; a blade shape of the troposkien type is adopted for the analysis. Results of the performance study indicate the marked influence of the wind speed Reynolds number and the need for correct airfoil data. J.M.B.

**A78-22239** Aerodynamic studies on vertical-axis wind turbine. N. V. C. Swamy (Indian Institute of Technology, Madras, India) and A. A. Fritzsche (Dornier System GmbH, Friedrichshafen, West Germany). In: International Symposium on Wind Energy Systems, Cambridge, England, September 7-9, 1976, Proceedings.

(A78-22226 07-44) Cranfield, Beds., England, British Hydromechanics Research Association, 1977, p. C5-73 to C5-80; Discussion, p. X41. 5 refs.

A description is presented of investigations which were conducted in West Germany and in India with the objective to improve the Darrieus type of motor. The conventional cross section of the blade for the Darrieus motor is that of a symmetrical airfoil section. Mathematical relations describing the blade geometry are presented and the behavior of the blade in a centrifugal force field is investigated, taking into account a comparison of the actual shape of the rotor blades with a quadratic parabola and a catenary for different rotor height-diameter ratios. The contribution to the torque provided by the various segments of the rotor is determined. There appears to be a distinct advantage in using a straight cylindrical section instead of curved blades. This hypothesis is to be investigated with the aid of a small model. G.R.

**N79-10533#** West Virginia Univ., Morgantown. DESIGN, INSTRUMENTATION, AND CALIBRATION OF A VERTICAL AXIS WIND TURBINE ROTOR M.S. Thesis

D. G. Elko 1977 112 p refs

(Contract EY-76-C-05-5135)

(TID-27754) Avail: NTIS HC A06/MF A01

A vertical axis wind turbine designed strictly for research purposes, in order to confirm theoretical performance calculations is described. Aerodynamic performance and structural analysis are emphasized. DOE

(SAND-77-0026) Aeroelastic analysis of the troposkien-type wind turbine. Ham, N.D. (Sandia Labs., Albuquerque, N.Mex. (USA)). Apr 1977. Contract EY-76-C-04-0789. 28p. Dep. NTIS, PC A03/MF A01.

The testing of troposkien-type wind turbines has indicated that under certain conditions serious vibrations of the blades can occur, involving flatwise bending, torsion, and chordwise bending. It is the purpose of this report to perform an aeroelastic analysis of the

stability of the coupled bending and torsional motion of such blades with a view to determining the cause of these vibrations as a means of suppressing them. The emphasis of the analysis is on obtaining physical understanding rather than exact numerical results. The effect of extreme variation of the chordwise location of the section center of gravity of troposkien-type rotor blades was found to be negligible with regard to blade flutter. This conclusion implies that chordwise mass balancing of the blades is not required, with consequent large reductions in blade design and manufacturing requirements, and therefore in blade cost.

**APPLICATION OF LAMINATED WOODEN BLADES TO A TWO-METER DAR-RIEUS TYPE VERTICAL AXIS WIND TURBINE.**

This paper describes the use of laminated Lauan plywood in a 2-meter-diameter, 3-bladed Darrieus wind turbine. The manufacture, testing and tensile stress analysis of laminated wooden blades are described. The 2-meter wind turbine model tests indicated that, with appropriate blade design, wood has potential for small vertical axis wind turbines. 13 refs.

Butler, B.L. (Sandia Lab., Albuquerque, NM); Blackwell, B.F. *SAMPE Q* v 8 n 2 Jan 1977 p 1-6.

**A78-32422** Blade design and fabrication - 17-meter VAWT. J. J. Barzda (Kaman Aerospace Corp., Bloomfield, Conn.). *Wind Technology Journal*, vol. 1, Spring, 1977, p. 17-22. Research supported by Sandia Laboratories.

Sandia Laboratories, Albuquerque, New Mexico, is erecting an experimental 17-meter vertical axis wind turbine (VAWT) power generating system. The subsystems are now being fabricated. The subject of this paper is the design and fabrication of the turbine rotor blades. The rotor will have three blades, stiffened with support struts. The design criteria, structural design, supporting engineering analysis, and fabrication methods are discussed. (Author)

**A78-22238** A contribution to the aerodynamic theory of the vertical axis wind turbine. O. Holme (Saab-Scania AB, Aerospace Div., Linköping, Sweden). In: International Symposium on Wind Energy Systems, Cambridge, England, September 7-9, 1976, Proceedings. (A78-22226 07-44) Cranfield, Beds., England, British Hydromechanics Research Association, 1977, p. C4-55 to C4-72; Discussion, p. X40, X41.

An analysis is made of the flow in the horizontal plane of symmetry of a fast running vertical-axis wind turbine having a great number of straight, very narrow blades and a high height-diameter ratio. The analysis is rigorously valid for only very lightly loaded turbines in incompressible nonviscous flow, but approximations for heavier loading and corrections for viscous effects are derived. It is found that half of the flow retardation caused by the turbine takes place within the turbine itself. Thus blade incidence and aerodynamic load on the blades are much higher on the windward than on the leeward side of the turbine. The maximum value of the power coefficient in nonviscous flow for this type of turbine is 92% of the theoretical maximum for an ideal wind turbine. (Author)



**Design, Instrumentation, and Calibration of a Vertical Axis Wind Turbine Rotor.**

D. G. Elko.

West Virginia Univ., Morgantown. 1977. 112p

TID-27754 Price code: PC A06/MF A01

The design, instrumentation and calibration of a vertical axis wind turbine that has been built by the Department of Aerospace Engineering at West Virginia University (WVU) are described. The turbine was designed strictly for research purposes, in order to confirm theoretical performance calculations developed by the Department. Areas of special interest are aerodynamic performance and structural analysis. (ERA citation 03.003144)

(SAND--77-1845C, pp 177-187) DATA ACQUISITION AND SIGNAL PROCESSING FOR SANDIA'S VERTICAL AXIS WIND TURBINE INSTALLATION. Stiefeld, B. 1977.

From Digital signal processing symposium; Albuquerque, NM, USA (6 Dec 1977).

Proceedings of the digital signal processing symposium.

The data acquisition and analyses system developed to meet the needs of the VAWT test site is described. The system employs a 16-BIT word length mini-computer as the CPU and includes a variety of peripheral devices for data acquisition and display. The data acquisition portion of the system includes an industrial A/D system and a specially designed PCM unit. These devices allow the acquisition of 120 channels of mixed low/high level signals and selectable acquisition rates. The software support system allows near real time display of graphic output of various types. Included are a file system to allow combining of data acquired over extended time periods, frequency analysis of structural response and wind performance, a "bin" oriented analysis of wind vs various turbine performance characteristics.

A78-18093

Design parameters affecting the performance of resistance-type, vertical-axis windrotors - An experimental investigation. S. Sivasegaram (University of Sri Lanka, Peradeniya, Sri Lanka). *Wind Engineering*, vol. 1, no. 3, 1977, p. 207-217. 7 refs.

**AN INEXPENSIVE METHOD FOR CONSTRUCTING DARRIEUS BLADES.**

D.P. Grimmer and C.D. Kolstad.

*Alternative Sources of Energy*, no.29, Dec.1977, p.14-20.

Inexpensive wind-power, particularly for small-scale applications, from vertical-axis Darrieus wind turbines has been hampered by high blade costs. This paper discusses a low cost blade design which is simple enough for construction by the home craftsman or small manufacturer. Materials costs are estimated at \$74 for a single 15' blade (1977 costs). Construction techniques as well as designs are discussed.

**Feasibility Investigation of the Giromill for Generation of Electrical Power. Volume I. Executive Summary. Final Report, April 1975--April 1976.**

R. V. Brulle.

McDonnell Aircraft Co., St. Louis, Mo. Jan 77. 29p

COO/2617-76/1/1 Price code: PC A03/MF A01

The feasibility of the Giromill for the cost effective production of electrical energy is studied. Twenty-one different Giromill configurations covering three sizes of Giromill systems (120, 500 and 1500 kW) were analyzed, varying such parameters as rotor solidity, rotor aspect ratio, rated wind velocity, and number of rotor blades. The Giromill system analysis employed the same ground rules being used for conventional windmill analyses to facilitate comparisons between these systems. The results indicate that a Giromill is a very efficient device, and coupled with its relatively simple construction appears quite cost effective when compared to conventional windmills. (ERA citation

A78-18092

Performance characteristics of concentrator-augmented Savonius wind rotors. A. Sabzevari (Pahlavi University, Shiraz, Iran). *Wind Engineering*, vol. 1, no. 3, 1977, p. 198-206.

This paper describes the performance characteristics of seven S-rotor configurations tested in the wind tunnel to study the effect of wind concentrator, diffuser and ducting on the tip speed ratio and power output. The configurations tested included both continuous and split S sections. (Author)

N78-25632# Sandia Labs., Albuquerque, N. Mex. Aerodynamics Div

**FREE-AIR PERFORMANCE TESTS OF A 5-METRE-DIAMETER DARRIEUS TURBINE**

R. E. Sheldahl and B. E. Blackwell Dec. 1977 36 p refs

(Contract EY-76-C-04-0789)

(SAND-77-1063) Avail: NTIS HC A03/MF A01

The results of these tests and some of the problems associated with free air testing of wind turbines are presented. The performance data obtained follow the general trend of data obtained in extensive wind tunnel tests of a 2 meter diameter turbine. However, the power coefficient data are slightly lower than anticipated. The reasons for this discrepancy are explored along with comparisons between experimental data and a computerized aerodynamic prediction model.

EHA

**Vertical Axis Wind Turbine Tie-down Design with an Example.**

R. C. Reuter, Jr.

Sandia Labs., Albuquerque, N. Mex. Dec 77, 35p

SAND-77-1919 Price code: FC A03/MF A01

Design of cable tie-down systems for vertical axis wind turbines is discussed and guidelines are furnished. Topics such as the number, size and material of the cables, cable elevation angle, tensioning, and thermoelastic effects are discussed in detail. The tie-down system of the existing Sandia 17 meter VAWT is used throughout as a numerical example. (ERA citation: 03-023571)

(COO-2617-4/1) Giromill wind tunnel test and analysis.

Volume I. Executive summary. Final report, June 1976—October 1977. Moran, W.A. (McDonnell Aircraft Co., St. Louis, Mo. (USA)). Oct 1977. Contract EY-76-C-02-2617. 20p. Dep. NTIS. PC A02/MF A01.

The study described herein is a continuation of the Giromill investigation in which a wind tunnel test of a model Giromill rotor was performed. The primary objective of the wind tunnel test was to obtain data for comparison with the Larsen cyclogiro vortex theory program employed for predicting the Giromill performance. The model had a rotor diameter of 7 ft. (2.13 meters) and a solidity (total blade area divided by rotor span times diameter) of 0.3. This was achieved by a three bladed rotor having blade chords of 3.4 in. (21.3 cm) and a span of 5 ft. (1.52 meters). The blades were modulated by use of replaceable cams, that simulated the various operating conditions, and a push rod arrangement connected to a bellcrank about the blade pivot point. Rotor RPM control was achieved with an electric motor/generator that could be used to either drive the rotor or absorb the rotor power to maintain RPM.

(SAND-76-0650) Engineering development status of the Darrieus wind turbine. Blackwell, B.F.; Sullivan, W.N.; Reuter, R.C.; Banas, J.F. (Sandia Labs., Albuquerque, N. Mex. (USA)). Mar 1977. Contract EY-76-C-04-0789. 67p. Dep. NTIS. PC A04/MF A01.

The aerodynamic, structural, and system considerations required for the engineering development of the Darrieus turbine are described. Particular emphasis is given to the necessity for close interaction of these three areas and their effects on energy costs. Currently available experimental data and analytical methods are discussed, together with specific results and trends obtained to date.

(SAND-77-1063) FREE-AIR PERFORMANCE TESTS OF A 5-METRE-DIAMETER DARRIEUS TURBINE. Sheldahl, R.E.; Blackwell, B.F. (Sandia Labs., Albuquerque, N. Mex. (USA)). Dec 1977. Contract EY-76-C-04-0789. 36p. Dep. NTIS. PC A03/MF A01.

A five-meter-diameter vertical-axis wind turbine has been tested at the Sandia Laboratories Wind Turbine Site. The results of these tests and some of the problems associated with free-air testing of wind turbines are presented. The performance data obtained follow the general trend of data obtained in extensive wind tunnel tests of a 2-meter-diameter turbine. However, the power coefficient data are slightly lower than anticipated. The reasons for this discrepancy are explored along with comparisons between experimental data and a computerized aerodynamic prediction model.

(SAND-77-1241) LIGHTNING PROTECTION FOR THE VERTICAL AXIS WIND TURBINE. Dodd, C.W. (Sandia Labs., Albuquerque, N. Mex. (USA)). Oct 1977. Contract EY-76-C-04-0789. 26p. Dep. NTIS. PC A03/MF A01.

The results of lightning protection studies for Vertical Axis Wind Turbines are presented. The methodology is established for determining the chances for a lightning strike at a VAWT site. Proposed designs for lightning protection systems are described. These designs include an insulator design, a brush by-pass design, a cone of protection, lightning elimination device, and a concentric tower protection system. The work also describes an effective grounding system.



A78-22242 A low cost windmill rotor. A. C. Baxter (Leicester, University, Leicester, England). In: International Symposium on Wind Energy Systems, Cambridge, England, September 7-9, 1976, Proceedings. (A78-22226 07 44) Cranfield, Beds., England, British Hydromechanics Research Association, 1977, p. C8-101 to C8-108; Discussion, p. X45, X46.

The economic feasibility of a use of windmills to obtain power for the generation of electricity depends primarily on the capital cost of the required installation. It appears that this capital cost is still too high. In this connection, a vertical axis, high speed rotor design has been proposed by Rangi et al. (1974), who estimate that the cost of their device would be about 1/6 of that of a conventional windmill. In the new windmill the expensive airfoil section blades, which form a main component of most windmills, are replaced with a simple steel framework round which a tensioned fabric cover is placed. A description is given of experiments in which models of the new airfoils are employed. Static aerodynamic tests of a vertical axis windmill rotor using flexible blades predict that the design appears promising. G.R.

TJ Greater Los Angeles Area Energy Symposium,  
163.2 1977.  
.G74 Greater Los Angeles Area Energy Symposium  
1977 ... c1977. (Card 4)  
ineers and Scientists. Proceedings series -  
Los Angeles Council of Engineers Scien-  
tists ; v. 3.

Multimegawatt Vertical Axis Windmills  
E. E. Lapin, The Aerospace Corporation

43

A78-37421 # Operational experience with a 5m Darrieus wind turbine. V. A. L. Chasteau (Auckland, University, Auckland, New Zealand). Institution of Engineers, Australian Hydraulics and Fluid Mechanics Conference, 6th, Adelaide, Australia, Dec. 5-9, 1977, Paper. 4 p. 11 refs.

A demonstration Darrieus wind turbine with a rotor diameter of 4.72 m was found to provide a power output much different from the output predicted by theory. Whereas a peak power of about 6 kW in a 14 m/sec wind was expected, the turbine in fact developed ever-increasing power with wind speed increments, registering a maximum output of 23 kW in a 22 m/sec wind. The relationship between power coefficient and tip speed ratio was studied on the basis of line current and windspeed records; the blade Reynolds numbers appeared to have a significant influence on the shape of the power coefficient curve. J.M.B.

A78-22237 A performance prediction model for the Darrieus turbine. J. H. Strickland (Texas Tech University, Lubbock, Tex.). In: International Symposium on Wind Energy Systems, Cambridge, England, September 7-9, 1976, Proceedings. (A78-22226 07 44) Cranfield, Beds., England, British Hydromechanics Research Association, 1977, p. C3-39 to C3-54; Discussion, p. X39, X40. 14 refs.

An analytical performance prediction model for the Darrieus turbine is described. Such a model is needed in connection with the recent interest in the Darrieus turbine as a wind energy conversion device. In an approach recently used by Templin (1974) the rotor is visualized as being enclosed in a single streamtube. In a more sophisticated model a series of streamtubes (actually stream filaments) are assumed to pass through the rotor. The development and utilization of such a multiple streamtube model is discussed. The basic aerodynamic model is first developed along with a description of a suitable iterative solution technique. A computer model is employed to predict the overall rotor power output and the distribution of aerodynamic forces along the rotor blades. The effects of rotor geometry variations can also be studied. G.R.

(SAND--77-1176) PRELIMINARY BLADE STRAIN GAGE DATA ON THE SANDIA 17-METER VERTICAL-AXIS WIND TURBINE. Sullivan, W.N. (Sandia Labs., Albuquerque, N.Mex. (USA)). Dec 1977. Contract EY-76-C-04-0789. 20p. Dep. NTIS, PC A02/MF A01.

Results are summarized from blade strain measurements made during the initial operating period of the Sandia 17 M turbine. The measurements indicate that the blade structure is performing adequately, without any apparent fatigue life consumption or excessive vibration. The test results cover a range of turbine speeds (from 29.6 to 59.3 RPM) and wind speeds (from negligible to 50 MPH).

N77-29613# Sandia Labs. Albuquerque, N. Mex. SANDIA VERTICAL-AXIS WIND TURBINE PROJECT Technical Quarterly Report, 1 Apr. - 30 Jun. 1976. R. C. Reuter, Jr., ed. and Robert E. Sheldahl, ed. Jan. 1977 78 p. refs. (Contract E(29-1) 789) (SAND-76-0581) Avail. NTIS HC A05/MF A01

Highlights for the quarter and status reports on activities in areas of systems studies aerodynamics, electrical systems, structures, and mechanical design are presented. Subheadings in each section cover general development activities and activities related to the 17-meter turbine and the 5-meter turbine. ERA

## SELECTED WIND TUNNEL TEST RESULTS FOR THE DARRIEUS WIND TURBINE.

B.F. Blackwell and R.E. Sheldahl.

J. Energy, v.1, no.6, Nov/Dec.1977, p.382-86.

**T**HE previously published experimental performance data for the Darrieus turbine are contained in a series of National Aeronautical Establishment/National Research Council of Canada (NAE/NRC) reports<sup>1,5</sup> and a NASA report.<sup>6</sup> In order to verify some of the earlier findings, expand the range of some of the pertinent parameters, and provide a comprehensive data base for the development of computer models for the prediction of aerodynamic performance and loads, an extensive wind tunnel test program was undertaken. This paper summarizes the primary results from the test program conducted at the Vought Corporation, Vought Systems Division Low-Speed Wind Tunnel.

A77-48897

Some contributions to aerodynamic theory for vertical axis wind turbines. H. Ashley (Stanford University, Stanford, Calif.). In: Intersociety Energy Conversion Engineering Conference, 12th, Washington, D.C., August 28-September 2, 1977, Proceedings, Volume 2. (A77-48701 23-44) La Grange Park, Ill., American Nuclear Society, Inc., 1977, p. 1624-1632. 27 refs. Grant No. AF-AFOSR-74-2712.

A review and modest extensions of quasi-steady aerodynamic theory for performance prediction on Darrieus-type turbines are presented. Results are given for both parallel-axis and curved-blade configurations. Blade stall and variable inflow are neglected; it is hypothesized that unsteady effects support the former approximation down to lower values of tip-speed ratio than hitherto believed. Both profile and induced drag are included, and their influences on power and downwind force are expressed in terms of elliptic integrals. Comparisons are presented with power data from the Sandia 2-meter turbine. Three values of profile drag coefficient are employed, and it is argued that numbers in the range drag coefficient range of 0.015-0.017 are most appropriate to the example chosen. A linearized analysis of unsteady-flow effects on performance is summarized. Calculations suggest that they may be larger than might be expected in view of the low operating reduced frequencies of these machines.

A78-22240

Status of the ERDA/Sandia 17-meter Darrieus turbine design. B. F. Blackwell (Sandia Laboratories, Albuquerque, N. Mex.). In: International Symposium on Wind Energy Systems, Cambridge, England, September 7-9, 1976, Proceedings. (A78-22226 07-44) Cranfield, Beds., England, British Hydromechanics Research Association, 1977, p. C6-81 to C6-86; Discussion, p. X42, X43.

A78-22235

Some design aspects of high-speed vertical-axis wind turbines. R. J. Templin and P. South (National Research Council, Ottawa, Canada). In: International Symposium on Wind Energy Systems, Cambridge, England, September 7-9, 1976, Proceedings. (A78-22226 07-44) Cranfield, Beds., England, British Hydromechanics Research Association, 1977, p. C1-1 to C1-20; Discussion, p. X37, X38.

The paper discusses the aerodynamic, mechanical and economic reasons for the choice of the various design parameters (rotor height to diameter ratio, solidity, number of blades, etc.) for high-speed vertical-axis wind turbines from kilowatt to megawatt sizes and shows that very large turbines are theoretically feasible. The paper also describes various methods to prevent overspeeding, to improve the starting characteristics, and to alleviate the effects of cyclic torque and drag loads. The operation of the turbine at constant efficiency is compared with operation at constant speed to show that as long as the rotor speed is properly selected the constant speed mode produces nearly as much average power as the constant efficiency mode. Finally, the economics of a large turbine feeding electrical energy into an existing thermal system are considered to show that under the right circumstances the use of wind energy makes considerable financial savings possible. (Author)

A78-22241

The variable geometry vertical axis windmill. P. J. Musgrove (Reading University, Reading, Berks., England). In: International Symposium on Wind Energy Systems, Cambridge, England, September 7-9, 1976, Proceedings. (A78-22226 07-44) Cranfield, Beds., England, British Hydromechanics Research Association, 1977, p. C7-87 to C7-100; Discussion, p. X44, X45. 9 refs. Science Research Council Grant No. B/RG/9233.8.

The Variable Geometry Vertical Axis windmill (VGVAW), which was recently developed in the UK, uses straight blades that are hinged to a horizontal cross-arm. In low wind speeds the blades remain upright, providing maximum efficiency when it is most needed. In high wind speeds centrifugal forces, reacted by a central spring which is attached via tie-wires to the blades, make the blades incline outwards. The blade inclination progressively increases with increasing wind speed. This approach makes it possible to prevent excessive blade stresses, regardless of the wind speed. The maximum power output is limited to a small multiple of the average power output. The design of the VGVAW is described in some detail. It is indicated how the predicted performance of the windmill varies with wind speed and load. A 3 meter diameter prototype VGVAW has recently been constructed at Reading, and initial observations of its performance are reported. G.R.

(SAND-76-0616) Tie-down cable selection and initial tensioning for the Sandia 17-meter vertical-axis wind turbine. Reuter, R.C. Jr. (Sandia Labs., Albuquerque, N.Mex. (USA)). Feb 1977. Contract EY-76-C-04-0789. 18p. Dep. NTIS, PC A02/MF A01.

The rationale used for selection of tie-down cables for the Sandia 17-meter turbine is presented, discussed and implemented. The effect of initial cable tension on the response of the tie-down system is evaluated and discussed in terms of resulting sag, blade interference and response linearity.

#### VAWT RESEARCH AT SANDIA LABS.

Joe Carter

Wind Power Digest, Summer 1977, p.42-45.

Sandia has been working on the vertical axis wind turbine since 1974, and they've come a long way from the first tests to their newest installation, a 17 meter Darrieus turbine.

A78-22244 WVU wind energy concentrators. J. L. Loth (West Virginia University, Morgantown, W. Va.). In: International Symposium on Wind Energy Systems, Cambridge, England, September 7-9, 1976. Proceedings. (A78-22226 07-44) Cranfield, Beds., England, British Hydromechanics Research Association, 1977, p. E2-17 to E2-30. 9 refs. NSF Grant No. AER-75-00367-000.

The paper describes three types of wind concentrators, by means of which the coefficient of performance of a wind turbine may be increased beyond the theoretical Betz limit. The first type consists of a cylindrical obstruction which increases the wind kinetic energy available for harnessing. The second type is a cylindrical Darrieus rotor, which acts like a porous cylindrical obstruction to the wind. For high solidity rotors the inner blockage will increase the wind speed experienced by those blades that operate near the maximum width. The third type is the wing tip vortex type concentrator, based on creating a horizontal tornado-like vortex with its axis aligned with the wind. The cylindrical Darrieus rotor features passive aerodynamic angle-of-attack control and automatic feathering.

P.T.H.

#### (SAND--77-1519) VERTICAL AXIS WIND TURBINE TIE-DOWN DESIGN WITH AN EXAMPLE.

Reuter, R.C. Jr. (Sandia Labs., Albuquerque, N.Mex. (USA)). Dec 1977. Contract EY-76-C-04-0789. 35p. Dep. NTIS, PC A03/MF A01.

Design of cable tie-down systems for vertical axis wind turbines is discussed and guidelines are furnished. Topics such as the number, size and material of the cables, cable elevation angle, tensioning, and thermoelectric effects are discussed in detail. The tie-down system of the existing Sandia 17 meter VAWT is used throughout as a numerical example.

#### VERTICAL WINDMILL GENERATES KILOWATTS FROM MONSOONS.

Susan Renner-Smith

Popular Science, vol. 210, no. 6, June 1977, page 99.

India's National Aeronautical Lab. Darrieus design.

#### Wind Tunnel Performance Data for Two- and Three-Bucket Savonius Rotors.

B. F. Blackwell, R. E. Sheldahl, and L. V. Feltz. Sandia Labs., Albuquerque, N.Mex. Jul 77, 107p. SAND-76-0131 Price code: PC A06/MF A01

Fifteen configurations of a Savonius rotor wind turbine were tested in the Vought Corporation Systems Division 4.9- x 6.1-m Low Speed Wind Tunnel to determine aerodynamic performance. The measured test variables were torque, rotational speed, and tunnel conditions. The data presented are in the form of power and torque coefficients as a function of speed ratio (or angular position for static starting torques). It is concluded that increasing Reynolds number and/or aspect ratio improves performance. The recommended configuration consists of two sets of two-bucket rotors, rotated 90 deg apart, with each rotor having a dimensionless gap width of 0.1 to 0.15.

#### N77-29612# Sandia Labs., Albuquerque, N. Mex. APPLICATION OF LAMINATED WOODEN BLADES TO A TWO-METER DARRIEUS TYPE VERTICAL AXIS WIND TURBINE

B. L. Butler and Bonnie F. Blackwell Dec. 1976 21 p refs (Contract E(29-1)-789) (SAND-75-0284) Avail: NTIS HC A02/MF A01

The use of laminated Lauan plywood in a 2-meter-diameter, 3-bladed Darrieus wind turbine is described. The manufacture, testing and tensile stress analysis of laminated wooden blades are described. The thin NACA 0012 blade was excited into resonance well below the peak power rpm and constrained the turbine to low power output. The 2-meter wind turbine model tests indicated that, with appropriate blade design, wood has potential for small vertical axis wind turbines.

ERA

A77-49096

The Darrieus Vertical-Axis Wind Turbine program at Sandia Laboratories. E. G. Kadlec (Sandia Laboratories, Albuquerque, N. Mex.). In: Sharing the sun: Solar technology in the seventies; Proceedings of the Joint Conference, Winnipeg, Canada, August 15-20, 1976. Volume 7. (A77-48910-23-44) Cape Canaveral, Fla., International Solar Energy Society, 1976, p. 349-359. 8 refs. ERDA supported research.

The vertical axis wind turbine (VAWT) consists of blades having an airfoil cross section which are attached at both ends to a vertical rotating shaft and has the following advantages over conventional turbines: no need for yaw control, the delivery of mechanical power at ground level, simple support tower construction, and no pitch control required for synchronous application. The program at Sandia Laboratories emphasizes the use of the VAWT operating at constant speed to generate electricity which is fed directly into a utility grid. The program has concentrated on the development of analytical capability in support of the VAWT design, the analyses partially confirmed by testing of the existing 5 meter turbine.

B.J.

### Wind and solar energy for water supply.

Proc. Int. Conf. on Appropriate Technologies for Semiarid areas - Wind and Solar Energy for Water Supply (W. Berlin : Sep. 15-20, 1975). German Fed. Rep., German Foundation for Int. Development, 1976, vii + 329 pp.

Contents: Part 1: Conditions and constraints for wind and solar energy in water supply; Part 2: Wind energy: Efficiency and economic comparison of different WEC - (wind energy convertor) rotor systems; Flapping-vane wind machine; 6,000 Hand-crafted sailing windmills of Lassithiou, Greece, and the relevance to windmill for Indian agriculture; An air-operated deep-well pump with two types of windmills; Simple anemometric equipment; Part 3: Solar pumping and electricity supply; Part 4: Solar distillation; Part 5: Research and development.



## WIND - TRANSPORTATION APPLICATIONS

PERFORMANCE MATCHING AND OPTIMIZATION OF WIND  
POWERED WATER PUMPING SYSTEMS. G. M. Bragg and  
W. L. Schmidit.

Energy Conversion, vol 19, no 1, 1979, p. 33-41.

**Abstract**—A procedure is presented which allows optimum selection of pumps and windmills for a given water pumping situation. When information on the wind, pump characteristics and windmill characteristics is available, the best pump and windmill for the application may be selected, and the design and oil design performance of the complete system may be predicted.

RURAL USE OF WIND POWER TO CONSERVE ENERGY RESOURCES,  
by Leo H. Soderholm, IEEE Transactions on Industry  
Applications, vol. IA-14, no. 6, Nov/Dec. 1978, p.492-  
497.

**Abstract**—Energy derived from the wind offers possibilities for supplementing rural power supplies. Basic concepts of wind-derived power and the possibilities of conserving energy, reducing electrical demand, and improving electrical system load factors are considered.

WIND-POWERED PROCESSING-II. Edgar A. Cadwallader,  
John E. Westberg.

Chemtech, vol 9, no 5, May 1979, p. 310-315.

How wind energy is used in chemical processing—in this case, desalination—provides the tie-up of *Cadwallader and Westberg's* analysis.

A79-37894 A low cost wind energy conversion system for heating of domestic premises. L. L. Freris, H. Bolton, I. K. Buehring, and V. C. Nicodemou (Imperial College of Science and Technology, London, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 282-285. Research supported by the University of London and Science Research Council.

AIR QUALITY POLICY & WIND ENERGY, by Donald Bain.  
Wind Power Digest, no. 14, Winter 1978, p.32-

Recent projections by electric utility and government planners alike call for massive expansions in generation capacity over the next twenty years. Sites must be found for these new power plants and the trend has been toward ever larger and more numerous facilities. The proponents of these new projects warn us that shortfalls in supply will occur if their expansion plans are either delayed or disapproved because of various regulatory policies. However, the addition of wind generating capacity to a utility's system on a large scale offers the possibility of mitigating some of the regulatory hurdles and offers an alternative strategy for the expansion of conventional generation capacity. This is because the use of wind energy in a fuel saving mode reduces the amount of oil burned to satisfy system demands over a period of time.



ANALYTICAL PERFORMANCE AND ECONOMIC EVALUATION OF RESIDENTIAL WIND OR WIND AND SOLAR POWERED HEATING SYSTEMS, by Ghazi Darkazalli and Jon G. McGowan. Solar Energy, vol. 21, no. 5, 1978, p.415-421.

In the windy northeastern region of the United States, a great potential exists for wind powered space and water heating of single family residences. The investigation of such systems has been under study at the University of Massachusetts for the past three years. In addition to detailed analytical performance and cost studies[1], as will be described in this paper, an experimental facility, Solar Habitat I, has been constructed[2] to experimentally verify the concept. Figure 1 shows the wind turbine generator installation at Solar Habitat I. For this study, a computer model[1,3] has been developed that simulates the effects of hourly wind, solar, and weather conditions on the performance and cost of a wind or wind and solar residential heating system. Although a great many subsystem options may be considered for integrated wind and combined wind and solar heating systems, the most promising ones have been identified by the use of this digital computer simulation.

ECONOMICS OF WIND ENERGY USE FOR IRRIGATION IN INDIA, by Sharat K. Tewari  
Science, vol. 202, no. 4367, November 1978, p. 481-486

Wind energy could be economically competitive for irrigation from open wells on small farms.

COST - EFFECTIVE ELECTRIC POWER GENERATION FROM THE WIND: A SYSTEM LINKING WIND - POWER WITH HYDROELECTRIC STORAGE AND LONG - DISTANCE TRANSMISSION.

C. J. Todd, R. L. Eddy, R. C. James, & W. E. Howell

Wind Engineering, Vol. 2, No. 1, 1978, p. 10-24.

*The idea of generating windpower at the windiest available sites (wind-farms) is examined for its effect on feasibility of large-scale windpower input to the nationwide electric power network in the United States of America. Windpower is considered in association with pumped-storage hydroelectric plants for load leveling and existing types of transmission lines for interconnecting the windfarms and energy-storage sites with load centers up to 2000 km away. Potential energy harvest from windfarm sites in the 17 western states is estimated at well over 100 GW, and many times this much in arctic North America. At the 100-GW level of development, bus bar cost at the windfarm would be about 3 mills/MJ (10 mills/kW-h). Energy storage required for load leveling would add about 1.8 mills/MJ and transmission costs another 2.1 mills/MJ, for a total cost at the load center of 6 mills/MJ (21 mills/kW-h), all in 1976 dollars. This would be competitive with energy generated near load centers by new nuclear or fossil-fuel power-plants. Windpower appears environmentally acceptable and avoids many of the environmental liabilities of conventional sources. Large-scale windpower implementation will require major advance commitment of capital, about \$1 billion, to lower bus bar costs to 4.4 mills/MJ (16 mills/kW-h). The timetable will, therefore, likely depend on Governmental incentives.*

THE CHARACTERISTICS OF A SAIL MILL

N.G. Calvert

J. Industrial Aerodynamics, vol 3, no. 1, March 1978  
p. 79-84

Irrigation wind pumps based on a modification of the Aegean type of con mill are associated with the eastern parts of the island of Crete [1]. During the past sixty years many thousands have been built by local blacksmiths. The author concludes from his travels and his studies that these mills have remained a local development which has not spread to other parts of the island.

TJ  
810  
.P53

**Pierson, Richard E., 1934-  
Technician's and experimenter's  
guide to using sun, wind, and water  
power / Richard E. Pierson. West  
Nyack, N.Y. : Parker Pub. Co., c1978.  
270 p. : ill. ; 24 cm. \$9.95  
Includes index.  
1. Solar energy. 2. Wind power. 3.**

This book is written for experimenters and technicians or anyone interested in building electrical generation units powered by the sun, wind, water, exercise and other FREE energy sources. Now you can benefit from reduced heating and electric bills with the advantage of having a virtually unlimited supply of fuel. -01-0

Unlike most of the information available on the market today, this guidebook gives you clear, easy-to-understand explanations of such topics as: specific design criteria; materials you need to build your own equipment; and inexpensive components that you can build yourself.

What's more, you'll find that all of the design problems handled in this guidebook are treated from the standpoint of MINIMUM COST so that no matter what your budget may be, you can join the elite group of solar experimenters.

**A79-15574 \*** Control of wind turbine generators connected to power systems. H. H. Hwang, H. V. Mozeico (Hawaii, University, Honolulu, Hawaii), and L. J. Gilbert (NASA, Lewis Research Center, Cleveland, Ohio). In: Power system control and protection. New York, Academic Press, Inc., 1978, p. 239-259. 16 refs. Research supported by the Hawaii Natural Energy Institute and NASA.

A unique simulation model based on a Mode-O wind turbine is developed for simulating both speed and power control. An analytical representation for a wind turbine that employs blade pitch angle feedback control is presented, and a mathematical model is formulated. For Mode-O serving as a practical case study, results of a computer simulation of the model as applied to the problems of synchronization and dynamic stability are provided. It is shown that the speed and output of a wind turbine can be satisfactorily controlled within reasonable limits by employing the existing blade pitch control system under specified conditions. For power control, an additional excitation control is required so that the terminal voltage, output power factor, and armature current can be held within narrow limits. As a result, the variation of torque angle is limited even if speed control is not implemented simultaneously with power control. Design features of the ERDA/NASA 100-kW Mode-O wind turbine are included. S.D.

**A79-10237** Advanced wind furnace systems for residential and agricultural heating and electrical supply applications. J. G. McGowan (Massachusetts, University, Amherst, Mass.) and P. H. Sarkisian (Carrier Corp., Syracuse, N.Y.). In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings. Volume 3. (A79-10001 01-44) Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 2074-2081. 22 refs. Research supported by the U.S. Department of Energy.

This paper summarizes the results of an analytical performance and economic evaluation of three advanced wind furnace heating systems. The work represents an extension of previous work on wind powered heating systems and extends this wind energy application to the supply of electricity as well as space and hot water energy loads for rural residences and farms. Details of the proposed systems and the analytical modeling of the overall system and subcomponents are presented as well as typical system energy and economic performance. (Author)

**A79-14290** Design of a direct wind energy converter to heat water by agitation in a closed tank. S. Neyeloff and W. W. Gunkel (Cornell University, Ithaca, N.Y.). *Wind Technology Journal*, vol. 2, Spring-Summer 1978, p. 12-17. 10 refs.

Results of a systematic design procedure to match the performance of a wind turbine to a direct water heating system using an agitator operating in an enclosed system are presented. With this system, shaft power delivered to the agitator from a wind turbine is directly converted to heat. The power required to drive the agitator is proportional to the cube of the angular velocity at high Reynolds number. Matching the water heater to the wind turbine permits the turbine to operate at its optimal power coefficient. Using dimensional analysis and a model approach, a suitable design equation was developed. The use of this equation to design a water heating system for a typical dairy farm is discussed. (Author)

**A78-42418** Cost effective electric power generation from the wind - A system linking wind power with hydroelectric storage and long distance transmission. C. J. Todd, R. L. Eddy, R. C. James, and W. E. Howell (U.S. Bureau of Reclamation, Engineering and Research Center, Denver, Colo.). *Wind Engineering*, vol. 2, no. 1, 1978, p. 10-24. 15 refs.

The generation of windpower at the windiest available sites in the U.S. is considered in association with pumped-storage hydroelectric plants for load-leveling and existing types of transmission lines for interconnecting the windfarms and energy storage sites with load centers up to 2000 km away. Potential energy harvest from windfarm sites in the 17 western states is estimated at well over 100 GW, and the yield in Arctic North America is estimated to be many times this much. At the 100-GW level of development, it is estimated that bus bar cost at the windfarm would be about 3 mills/MJ (10 mills/kWh), energy storage for load leveling would be about 1.8 mills/MJ, and transmission costs would be about 2.1 mills/MJ, for a total cost at the load center of 6 mills/MJ (21 mills/kWh), in 1976 dollars. M.L.

TL693 A LOW COST AERODYNAMIC HEATER REPRESENTING  
 .N3 A FULLY MATCHED LOAD FOR WIND ENERGY SYSTEMS.  
 1978 M.O. Lawson.  
 v.2 NACON 78 (IEEE 1978 National Aerospace and  
 Electronics Conference, v.2, 1978, p.874-

Wind energy is being recognized as a potential source of heat for homes and for many farm applications. Early realization of the broad use of wind energy for heating applications depends primarily on the total system cost. The major components of such a heating system that most likely would be considered today are a wind turbine, an alternator, a tower, and a heat storage system. This order of listing may also represent the present order of costs. However, the wind turbine is believed to be amenable to great reduction in costs while the alternator is not. Replacing the alternator with a mechanical heater, and in particular a heater acting on aerodynamic principles as does the wind turbine, can provide a significant lowering of system cost. Another advantage is an inherent matched load to the wind turbine output over the full range of wind speed operation which can represent a major portion of the control system.

USING WATER-PUMPING WINDMILLS, Part I, by Joe Carter.

Wind Power Digest, no. 14, Winter 1978, p.25-31.

### LOW POWER WINDMILL

John McGeorge

Alternative Sources of Energy

Vol. no. 30 February 1978

p. 50-53

I've been attracted to bicycle generators as a possible source of power for very low power applications. In many applications, little electric power is actually needed. The ordinary transistor AM-FM radio draws about 15 milliamperes (.015 amps), at 6 volts.

This is well within the output range of a very small windmill. Other applications are low-power, battery-trickle charging of boat and car batteries. You will see how simple this is as you read on.

### COST-EFFECTIVE ELECTRIC POWER GENERATION FROM THE WIND: A SYSTEM LINKING WIND-POWER WITH HYDROELECTRIC STORAGE AND LONG-DISTANCE TRANSMISSION.

C.J. Todd, R.L. Eddy, R.C. James, W.E. Howell.

Engineering & Research Center, Bureau of Reclamation, Department of the Interior, Denver, Colorado 80225, U.S.A.

*Wind Engineering*. 1978, Vol.2, 1, 10-24.

The idea of generating windpower at the windiest available sites (wind-farms) is examined for its effect on feasibility of large-scale windpower input to the nationwide electric power network in the United States of America. Windpower is considered in association with pumped-storage hydroelectric plants for load leveling and existing types of transmission lines for interconnecting the windfarms and energy-storage sites with load centers up to 2000 km away. Potential energy harvest from windfarm sites in the 17 western states is estimated at well over 100 GW, and many times this much in arctic North America. At the 100-GW level of development, bus bar cost at the windfarm would be about 3 mills/MJ (10 mills/kW-h). Energy storage required for load leveling would add about 1.8 mills/MJ and transmission costs another 2.1 mills/MJ, for a total cost at the load center of 6 mills/MJ (21 mills/kW-h), all in 1976 dollars. This would be competitive with energy generated near load centers by new nuclear or fossil-fuel powerplants. Windpower appears environmentally acceptable and avoids many of the environmental liabilities of conventional sources. Large-scale windpower implementation will require major advance commitment of capital, about \$1 billion, to lower bus bar costs to 4.4 mills/MJ (16 mills/kW-h). The timetable will, therefore, likely depend on Governmental incentives.

A78-49842

The application of small wind powered generators in telecommunications and other high reliability systems. A. J. A. Hinsley and D. A. D. Smith (Pye Telecommunications, Ltd., Cambridge, England). *Wind Engineering*, vol. 2, no. 2, 1978, p. 115-126. 9 refs.

The use of 2-kW wind-powered generators of proven design to provide a highly reliable source of power for radio communication is discussed. Australian experience in using wind generators to provide power for remote sites is surveyed, and power requirements for different purposes are calculated. Engineering of systems is considered, and the total cost of wind-power generators, tower, energy storage, control equipment, and necessary buildings and foundations is estimated to be in the order of 8500 British pounds to supply a load of 200 watts. This form of wind-powered generation is economically justifiable only if the expenses involved in providing a connection with a cheap electricity source are considered in comparison.

M.L.

TJ 163.2 .S55 1977  
 Ship Technology and Research (STAP)  
 Symposium, 2d, San Francisco, 1977.  
 Proceedings; held in conjunction with  
 the STAP spring meeting hosted by the  
 Northern California Section. — New York :  
 Society of Naval Architects and Marine  
 Engineers, c1977.  
 vii, 516 p. : ill. ; 29 cm.  
 Held May 25-27, 1977.  
 Includes bibliographical references.

Updating an Ancient Art—Research and Development Toward  
 Modern Wind-Powered Cargo Ships..... 1  
 by William L. Warner and Miklos M. Kossa

Study of Alaskan Wind Power and Its Possible Applications.  
 Final Report, 1 May 1974--30 January 1976.  
 T. Wentink, Jr.  
 Alaska Univ., College. Geophysical Inst. 29 Feb 76, 183p  
 NSF/RANN/SE/AER-74-00239/FR-76/1 Price code PC  
 A09/MF A01

The program objective is to determine the wind power potential of Alaska, in both the meteorological and applied senses. The wind potential of the world is also treated. Specific goals are the determination of alternative applications and users of wind systems, optimum sites for these, and environmental problems associated with windmills used in Alaska. The program consists of seven tasks. In these, wind literature is surveyed (37 sites in depth and 30 more in less detail) and new wind measurements featuring vertical profiles of velocity are reported (2 sites). Considerable efforts on analytical formulations of measured and synthetic wind spectra are detailed. Environmental problems are treated, and several recommendations concerning the design of wind machines are made. Also, local energy use patterns and storage systems are considered, and the economics of windmill use, fuel costs, and fossil-based electricity are presented for Alaska. Guidance to a related separate Scientific Report is included. (ERA citation 02:022090)

TJ 163.2 .G74 1977  
 Greater Los Angeles Area Energy Symposium,  
 1977.  
 Greater Los Angeles Area Energy Symposium:  
 Tuesday, April 26, 1977 ... Los Angeles,  
 California / sponsored by the Los Angeles  
 Council of Engineers and Scientists, under  
 the auspices of the Los Angeles Section of  
 the American Nuclear Society ... [et al.]

The Anemometer: A New Instrument for Wind Power Site  
 Selection  
 C. P. Hoult, Windspeed, Inc.

51

How to Make Fertilizer from Wind, Air and Water  
 Michael Dubey, Lockheed-California Company

62

A77-48094 Large windpower systems integrated with existing electric utilities. R. T. Smith, R. K. Swanson, C. C. Johnson (Southwest Research Institute, San Antonio, Tex.), C. Ligon (Southwestern Public Service Co., Amarillo, Tex.), J. Lawrence, and D. Jordan (Texas Tech University, Lubbock, Tex.). In: Sharing the sun: Solar technology in the seventies; Proceedings of the Joint Conference, Winnipeg, Canada, August 15-20, 1976. Volume 7. (A77-48910 23-44) Cape Canaveral, Fla., International Solar Energy Society, 1976, p. 317-327. Contract No. E(11-1)-2621.

This paper reports a study of the feasibility of the use of wind turbine generators as supplemental energy sources on an existing electric utility network. The time frame is the period of the next two decades. Specifically, the study is centered upon the geographical region served by Southwestern Public Service Company, an investor owned utility with present capacity of approximately 2200MW. It includes the panhandles of Texas and Oklahoma, parts of eastern New Mexico and some communities in southwestern Kansas. Of prime importance, this region exhibits the highest wind energy potential of any area of comparable size in the continental United States.  
 (Author)

A78-18094 Speed polar of a wind turbine powered cargo boat. R. Flatt (Lausanne, Ecole Polytechnique Fédérale, Lausanne, Switzerland). *Wind Engineering*, vol. 1, no. 3, 1977, p. 218-230. 7 refs.

A calculation procedure is derived for the speed of a boat propelled by a wind turbine. The calculation, which does not consider Reynolds number effects, requires three dimensionless physical parameters and two interdependent variables. When applied to a 45,000 ton cargo boat, a nearly circular polar, having an average speed of about 4 m/s for an assumed true wind speed of 10 m/s, is obtained.  
 S.C.S.



**N78-27582#** Brookhaven National Lab., Upton, N. Y.  
**ROLE OF WIND POWER IN ELECTRIC UTILITIES**  
H Davitian Sep 1977 22 p refs  
(Contract EY-76-C-02-0016)  
(BNL-50736) Avail: NTIS HC A02/MF A01

Current estimates suggest that the cost of wind generated power is likely to be competitive with conventionally generated power in the near future in regions of the United States with favorable winds and high costs for conventionally generated electricity. This assessment regarding competitiveness includes effects of reduced reliability of wind power compared to conventional sources. Utilities employing wind power are likely to purchase more peaking capacity and less baseload capacity than they would have otherwise to provide the lowest cost reserve power. This reserve power is needed mainly when wind outages coincide with peak loads. The monetary savings associated with this shift contribute substantially to the value of wind energy to a utility. ERA

**N78-14645#** General Electric Co., Philadelphia, Pa. Space Div.  
**WIND ENERGY MISSION ANALYSIS, EXECUTIVE SUMMARY**  
18 Feb 1977 28 p  
(Contract EY-76-C-02-2578)  
(COO-2578-1-1) Avail: NTIS HC A03/MF A01

High-potential applications, functional, performance, operational, and cost goals for wind energy conversion systems and the impact of the wide-scale deployment of such systems on energy users were evaluated. The institutional and nontechnical problems associated with the acceptance of wind energy were also studied. Emphasis was placed on identifying and exploring high-aggregate energy users who have significant potential to utilize wind energy in place of other alternatives. ERA

**A78-32506** Empirical and theoretical statistics of wind-charger home heating potential. S. Stolt and R. L. Kirlin (Wyoming University, Laramie, Wyo.). *Wind Technology Journal*, vol. 1, Fall 1977, p. 21-25.

Application of wind energy to home heating has drawn considerable interest recently and several windchargers are currently available at a small fraction of the average cost of a new home. The performance and economics of one of these is studied by using weather and home heating statistics at two geographical locations. It is shown that for the example chosen, wind energy is not quite economical. Due to the cooling effect of the wind, a statistical correlation between power availability and power demand was sought. However, this was not shown to be the case. The implication is that heat storage capability is necessary for high efficiency.

(SAN-1101-76/2) Wind machines for the California Aqueduct. Volume II. Final report. Aerospace report No. ATR-76(7536-01)-1 Vol. II. Lindley, C.A. (Aerospace Corp., El Segundo, Calif. (USA). Energy and Transportation Div.). Mar 1977. Contract EY-76-C-03-1101-005. 204p. Dep. NTIS, PC A10/MF A01.

A study was made of the feasibility of using wind machines to provide part of the energy required to pump water in the California Aqueduct. The need for additional pumping power for the Aqueduct will be especially felt in 1983 when existing arrangements which assure deliveries of low-cost energy from four California utilities terminate. The development and production schedule for the ERDA/NASA 1500 kW wind machine design as now understood could support the installation of a wind energy system to meet a significant portion of the Aqueduct needs by that date if few delays are encountered. This application of wind energy was found to be technically feasible, but would involve some operational problems. The Aqueduct application may be attractive for an early wind energy pilot or demonstration project because of the near-term ability of the Aqueduct to adapt its demand to the variability of the wind.

**N78-21620#** Williamson Engineering Associates, Inc., Navarre, Fla.  
**THE APPLICATION OF WIND ENERGY SYSTEMS TO DESALINATION**  
William R. Williamson, John E. Westberg, and William R. Williamson 22 Apr 1977 68 p refs  
(Contract DI-14-34-0001-7523)  
(PB-276174/0; W78-02701; OWRT/S-78/1) Avail: NTIS HC A04/MF A01 CSCL 10B

The application of wind energy systems to membrane processes for brackish water conversion is presented. Commercially available wind turbines and those under development were available for producing electrical energy at costs ranging from

(COO-2578--1/1) **WIND ENERGY MISSION ANALYSIS. EXECUTIVE SUMMARY.** (General Electric Co., Philadelphia, Pa. (USA). Space Div.). 18 Feb 1977. Contract EY-76-C-02-2578. 28p. Dep. NTIS, PC A03/MF A01.  
The principal objectives of this study were (1) to assess the potential for wind energy conversion systems on a national scale, (2) identify high-potential applications for WECS, (3) define functional, performance, operational, and cost goals for WECS, (4) evaluate the impact of the wide-scale deployment of WECS on energy users, and (5) identify the institutional and non-technical

**N78-21654#** Energy Task Force, Inc., New York.  
**WINDMILL POWER FOR CITY PEOPLE Final Report**  
Mary Christianson May 1977 73 p  
(Grant CSA-20156)  
(PB-275658/3; OEO-LN-2137) Avail: NTIS HC A04/MF A01 CSCL 10B

Findings show that the energy produced from the windmill is an important renewable energy resource which can be used in most urban areas and which reduces dependency on utility companies. A brief history of the windmill's origin, design and installation procedures are outlined. Also included are comparisons of energy savings of the windmill energy versus the utility companies. An appendix consists of literature, resources, a wind speed and direction map, structural engineering calculations and an explanation of windforces on windmills. GRA

**N78-14647#** General Electric Co., Philadelphia, Pa. Space Div.  
**WIND ENERGY MISSION ANALYSIS, APPENDICES A-J Final Report**  
18 Feb 1977 504 p  
(Contract EY-76-C-02-2578)  
(COO-2578-1-3) Avail: NTIS HC A22/MF A01

Information is presented concerning meteorological data and supporting analyses, gross energy consumption patterns and end-use analysis, as well as analysis for industrial applications of wind energy conversion systems (WECS). Also presented is an analysis for residential applications of WECS, an analysis for application of WECS to communities remote from utility grids.

**N78-14646#** General Electric Co., Philadelphia, Pa. Space Div.  
**WIND ENERGY MISSION ANALYSIS Final Report**  
18 Feb 1977 252 p refs  
(Contract EY-76-C-02-2578)  
(COO-2578-1-2) Avail: NTIS HC A12/MF A01

The development of wind energy systems in the U.S. is discussed under the following headings: baseline power systems, assessment of wind potential, identification of high potential applications, electric utilities, residential application, paper industry application, agriculture application, and remote community applications. ERA

**A77-48900 \*** An assessment of wind-powered generators for navigational aids. G. Herrera, H. Weiner (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.), and D. Nelson (U.S. Coast Guard, Washington, D.C.). In: Intersociety Energy Conversion Engineering Conference, 12th, Washington, D.C., August 28-September 2, 1977, Proceedings. Volume 2. (A77-48701 23-44) La Grange Park, Ill., American Nuclear Society, Inc., 1977, p. 1660-1667. 10 refs. Contract No. MIPR-Z-70099-5-50352.



A77-48901 Design and operational evaluation of a 25 kW wind turbine generator for residential heating applications. D. E. Cromack, W. E. Heronemus, and J. G. McGowan (Massachusetts University, Amherst, Mass.). In: Intersociety Energy Conversion Engineering Conference, 12th, Washington, D.C., August 28-September 2, 1977, Proceedings, Volume 2. (A77-48701 23-44) La Grange Park, Ill., American Nuclear Society, Inc., 1977, p. 1668-1675. 6 refs. Contract No. E(49-18)-2365.

A78-22251 A performance-optimised wind energy conversion system for space heating. L. L. Freris (Imperial College of Science and Technology, London, England). In: International Symposium on Wind Energy Systems, Cambridge, England, September 7-9, 1976, Proceedings. (A78-22226 07-44) Cranfield, Beds., England, British Hydromechanics Research Association, 1977, p. X60, X61; Discussion, p. X61, X62.

A78-32503 Reversible thermodynamics of the airlift pump. R. E. Barieau (West Texas State University, Canyon, Tex.). *Wind Technology Journal*, vol. 1, Fall 1977, p. 4-7. 5 refs. Research supported by the West Texas State University.

Formulas for calculating the reversible work required for pumping water by means of the airlift are derived. A sample calculation is presented. It is suggested how the reversible work could be used to calculate the parameters in an actual airlift installation.

(Author)

More than oil and gas to North Sea energy. Koekebakker, J. *Irrig. & Power*, 33, 2, Apr. 1976, pp. 240-242. (Also in *Energy Int.*, 12, 5, May, 1975, pp. 18-19).

This report is about the utilisation of wind power in the North Sea, and briefly presents some basic design concepts for wind turbines used in this application. (F. C. S.).

(ERDA/NSF/00833-75/1) Wind-powered aeration for remote locations. Final report, March 15, 1975-August 31, 1976. Schierholz, P.M.; Somervell, W.L. Jr.; Babcock, W.; Hartel, R.; Timbre, K. (Colorado Div. of Wildlife, Fort Collins (USA), Colorado State Univ., Fort Collins (USA)). Oct 1976. Contract NSF-G-AER-75-00833. 152p. Dep. NTIS, PC A95/MF A01.

Wind-powered aerators were installed and operated at three fish winterkill lakes and at a sewage lagoon. A wind-powered aerator is a system that converts the energy in the wind directly into compressed air which can be used in an aeration process. No auxiliary energy storage is required in that the lake acts as a storage device for the oxygen. None of the lakes where wind-powered aerators were installed experienced fish winterkill during the 1975-1976 winter. Wind-powered aeration shows promise for increasing sewage lagoon capacity only under severe weather conditions. The most desirable wind-powered aerator would be an American Wind Turbine driving a rotary blower mounted on a single pole tower. The winds are of sufficient strength and frequency for wind-powered aeration in northeastern Colorado and southeastern Wyoming, between the Front Range and the Continental Divide.

Wind Powered aeration for remote locations. Progress report 3/5/75-3/15/76.

Schierholz, P.M., Somervell, W.L., Babcock, W., Hartel, R. and Watson, K.

Colorado State Univ., U.S.A., April 1976, 74pp. (NSF/RA-76238)(PB 259 304).

This research concerns the use of wind power directly to compress air to increase oxygen levels in polluted rivers and lakes subject to winterkill. A prime advantage may be using the water for storage of oxygen eliminating requirements for energy storage such as batteries. Three sites are proposed for the installation of wind powered systems. One is a lake chosen on the high plains for ease of access, another is a high mountain lake subject to winterkill and the third is a high plains river with pollution problems. Extensive weather measurements will be made at the two lake sites which include both mountain and high plains characteristics. The objective is to gather data to investigate the use of wind powered aerators, correlation of local weather data with system performance, and further development of design correlations for small wind powered systems. (A.) (Microfiche).

PRELIMINARY ASSESSMENT OF THE POTENTIAL FOR MEDIUM AND LARGE CAPACITY WIND GENERATORS USED AS FUEL SAVERS FOR AC DIESEL BASED POWER SYSTEMS IN ONTARIO. In both the low power case (< 10 kw) and high power case (> 100 kw) the criteria for competitive operation of a wind/diesel hybrid power system appears to be greater than 12.5 mph mean annual wind speeds and diesel fuel costs of greater than \$1.00 per gallon. A number of telecommunications and community power sites in Northern Ontario meet these criteria so that a 'proof of concept' experiment is planned to validate the assumptions used in the analyses and to develop the coupling and control systems for wind/diesel systems. 5 refs.

Higgin, R.M.R. (Ont. Minist. of Energy, Toronto); Brown, C.K. *Sharing the Sun: Sol Technol in the Seventies, 11 Conf of the Int Sol Energy Soc., Am Sect and Sol Energy Soc of Can, Inc., Winnipeg, Manit, Aug 15-20 1976* Publ by Int Sol Energy Soc, Am Sect, Cape Canaveral, Fla, 1976 v 7 p 180-194.

X. OCEAN/WATER . . . . .	969
A. General . . . . .	970
B. Currents, Waves, and Osmotic Cells . . . . .	977
C. Thermal Gradients . . . . .	985
D. Hydroelectric (Including Tidal) . . . . .	1017

# OCEAN - GENERAL

36092 Energy from the oceans: requirements and capabilities. Richards, A. F. (Lehigh Univ., Bethlehem, PA) pp 91-129 of Ocean resources utilization. Monney, N. T. (ed.). New York, NY; American Society of Mechanical Engineers (1976).

From Winter meeting of the ASME, New York, NY, USA (5 Dec 1976).

Eight methods, and a number of variants, of obtaining energy from the ocean are presented: ocean thermal, kelp bioconversion, ocean waves, tides and tidal currents, ocean winds, ocean currents, salinity gradients, and ocean geothermal. Each method is discussed in terms of concepts, geographic areas applicable, and development schedule and costs insofar as information is available. None of these methods releases excess heat into the environment, as do fossil-fuel and nuclear power generating plants. Most of the methods represent relatively new technologies. The needs for seafloor engineering R D to support all ocean energy systems center about six principal areas: mooring and anchoring systems; anchor-soil interaction; underwater electrical-transmission cable-soil interaction; in-situ soil properties and soil behavior under applied loads for continental shelf siliceous and calcareous sands, and deep-sea pelagic clays and biogenic oozes; stability-instability relationships of shelf, slope, and deep-sea floor soils; and scour and stability of structures, including large anchors and power cables, with respect to liquefaction, wave loading, and structure-soil interaction in storms. 110 references.

TJ Energy Technology Conference, 5th, Washington, D.C., 1978.

.E4787 Energy technology V : challenges to technology : proceedings of the fifth Energy Technology Conference, February 27-March 1, 1978, Washington, D.C. / edited by Richard F. Hill. -- Washington : Government Institutes, 1978.  
xiii, 1063 p. : ill.

OCEAN ENERGY UNLIMITED

David D. Woodbridge, Associate, Watson and Associates, Inc.

p. 664

TK  
1081  
.M26

McGuigan, Dermot, 1949-

Harnessing water power for home energy / by Dermot McGuigan. -- Charlotte, Vt. : Garden Way Pub. Co., c1978.  
v, 101 p. : ill. ; 23 cm.  
Bibliography: p. 97-100.  
Includes index.

ISBN 0-88266-116-7

1. Water-power electric plants. I.  
Title.

A79-14719

Wind, waves, and tides. M. F. Merriam (California, University, Berkeley, Calif.). In: Annual review of energy. Volume 3. (A79-14718 03-44) Palo Alto, Calif., Annual Reviews, Inc., 1978, p. 29-56. 54 refs.

Wind, waves, and tides are of interest today as possible future energy sources primarily because of their nondepletable character and their favorable environmental aspect, in comparison with energy technologies presently in use. Studies comparing the cost of energy often have difficulties making a case for immediate economic viability of the renewable sources. If, however, oil and gas resources of the world do in fact become progressively and substantially depleted over the next 25 years, price increases and shortages will ensue and implementation of presently uneconomic alternatives will occur on a large scale. A review is presented of the present state of knowledge and experience with wind, wave, and tidal energy. The power density in the wind may, at a good site, average some hundreds of watts per square meter. Wave power being transported across a plane perpendicular to the wave propagation direction, at a good site, is from 10-100 times as large. Questions concerning the value of energy from an intermittent source are also considered. G.R.

NEW CAREER PATHS IN ENGINEERING - OCEANS  
William E. Heronemus

Mechanical Engineering, July 1977, vol. 99,  
no. 7, p. 46 - 47

The waters of the seas constitute the largest powerhouse on earth, one that in the future will require the employment of thousands of engineers. Essentially all of the traditional engineering disciplines have a role to play here. However, the need is vital for the engineer working in this field to have a basic understanding of marine science, as well as a willingness to protect this magnificent, finite resource.

Energy from the oceans fact or fantasy? : Conference proceedings, January 27-28, 1976, Raleigh, North Carolina / edited by Jerome Kohl ; sponsored by Coastal Plains Center for Marine Development Services ... [et al.]. — Raleigh : Center for Marine and Coastal Studies, North Carolina State University : may be obtained from Division of Continuing Education, NCSU. [1976]

110 p. : ill. : 28 cm. — (Report - Center for Marine and Coastal Studies, North Carolina State University ; no. 76-1) (Sea grant publication ; UNC-SG-76-04)

I. Ocean thermal power plants—Congresses. 2. Tidal power-plants—Congresses. 3. Ocean waves—Congresses. 4. Ocean currents—Congresses. 5. Salinity—Congresses. 6. Wind power—Congresses. I. Kohl, Jerome. II. Coastal Plains Center for Marine Development Services. III. Series: North Carolina State University, Raleigh. Center for Marine and Coastal Studies. Report - Center for Marine and Coastal Studies, North Carolina State University ; no. 76-1. IV. Series: Sea grant publication (Raleigh) ; UNC-SG-76-04.

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76-624604  
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1505  
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Ocean resources utilization : [papers] : presented at the winter annual meeting of the American Society of Mechanical Engineers, New York, New York, December 5-10, 1976 / sponsored by the Ocean Engineering Division, ASME ; edited by Neil T. Monney.

Energy From the Ocean: Requirements and Capabilities

Adrian F. Richards ..... p. 91

The extraction of renewable energy from the oceans has the long term potential of satisfying much of the world's requirement for energy, while producing minimal adverse environmental impact and virtually none of the security and waste disposal problems associated with nuclear power plants. Eight methods, and a number of variants, of obtaining energy from the oceans are presented: ocean thermal, kelp bioconversion, ocean waves, tides and tidal currents, ocean winds, ocean currents, salinity gradients, and ocean geothermal. Each method is discussed in terms of concepts, geographic areas applicable, and development schedule and costs insofar as information is available. None of these methods releases "excess" heat into the environment, as do fossil-fuel and nuclear-power generating plants. Most of the methods represent relatively new technologies.

The needs for seafloor engineering R & D to support all ocean energy systems center about six principal areas: mooring and anchoring systems; anchor-soil interaction; underwater electrical-transmission cable-soil interaction; in-situ soil properties and soil behavior under applied loads for continental shelf siliceous and calcareous sands, and deep-sea pelagic clays and biogenic oozes; stability-instability relationships of shelf, slope, and deep-sea floor soils; and scour and stability of structures, including large anchors and power cables, with respect to liquefaction, wave loading, and structure-soil interaction in storms.

SEA WATER: THE ENERGY ELIXIR  
Mark D. Zimmerman

Machine Design, vol. 49, no. 16, July 7, 1977,  
p. 20-26

Power may be wrested from the oceans by taking advantage of key differentials. This article looks at hardware designed to operate on thermal gradients, tidal heads, wave motions, and chemical variations.

CN-150,517 1978  
**ENERGY FROM THE OCEAN.** (Rept. prepared for the Subcommittee on Advanced Energy Technologies and Energy Conservation Research, Development and Demonstration of the Committee on Science and Technology, U.S. House of Representatives, 95th Congress, 2nd Session by the Science Policy Research Div., Congressional Research Service, Library of Congress). Apr. 1978. 433p. (Committee Print).

95th Congress, 2nd Session  
 95th Congress, 2nd Session Serial CC  
 Committee on Science and Technology

**Power sources, Ocean**  
**Hearings - Committee on Science and Technology**

TJ Pierson, Richard E., 1934-  
 810 Technician's and experimenter's  
 .P53 guide to using sun, wind, and water  
 power / Richard E. Pierson. West  
 Nyack, N.Y. : Parker Pub. Co., c1973.  
 270 p. : ill. ; 24 cm. \$9.95

**6. Unlimited Free Energy Sources - 97**

How to Use Moving Water (97) Calculating Water Power (99) How to Use Muscle Power (103) How to Use Potential Energy (104) Using Stored Pressure (105) Identifying Other Free Energy Sources (105)

**12. How to Make a Water Wheel - 203**

Design Guides (203) Detailed Description (205) The Wheel (205) Water Wheel Bearings and Side Boxes (209)

**LIFTING FOILS TAP ENERGY OF FLOWING AIR OR WATER**

Ben Kocivar  
 Popular Science  
 Vol. 212 no. 2 Feb. 1978  
 p. 71-73, 148.

TC International Symposium on Wave and Tidal  
 147 Energy, University of Kent, 1978.  
 .I5 Papers presented at the International  
 1978 Symposium on Wave and Tidal Energy held at  
 v.1 the University of Kent, Canterbury, England,  
 September 27-29, 1978. Volume 1 / organized by BHRA Fluid Engineering ; editors, H. S. Stephens, Mrs. C. A. Stapleton. -- Cranfield, Bedford, Eng. : BHRA Fluid Engineering, c1978.

Proposals for wave and tidal energy plants, economic analyses of plant operation and integration into existing power networks, and experimental results on pilot facilities are reported. Topics studied include a theory of wave power absorption by two independently oscillating bodies, an 18-m long buoy with pneumatic chambers and eleven generators producing 1.25 MW for 3-m wave height, wave power systems for desalination, optimum sites for tidal power development in the Bay of Fundy, design and construction of marine structures for wave/tidal ocean thermal energy, and integrating wave power into the electricity supply system. P.T.H.

NA Davis, Albert J.  
 2542.3 Alternative natural energy sources in  
 .D38 building design ... [1977], c1974.  
 1977

FIVE WATER POWER.....	87
5.1 Introduction.....	87
5.2 Dam location and flow measurement...	88
5.3 Dam type and construction.....	91
5.4 The wheel.....	93
5.5 The hydraulic ram..	97

A79-42350 Ocean and energy (Océan et énergie). A. Brin. Paris, Editions Technip, 1979. 122 p. 12 refs. In French.

The present and possible future role of the world's oceans in energy production and exploitation is examined. The impact of sea-based oil production on the marine environment is discussed, and methods used in developing undersea oil beds are described. Attention is given to the use of nuclear energy in boats, radioactive pollution of the oceans, the effects of large-scale use of seawater to cool reactors, and the possible exploitation of uranium in seawater. A second section discusses the present status of research concerning the use of sea-based alternative energy sources, including tides, waves and currents, temperature differences between surface and underlying water layers, and osmotic pressure. Applications of wind and solar energy in maritime activities are considered. C.K.D.



## OCEAN - CURRENTS, WAVES, AND OSMOTIC CELLS

79A40199# ISSUE 17 PAGE 3233 CATEGORY 44  
79/06/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Optimization of power absorption from sea waves

AUTH: A/BAZ, A.; B/EZZ, M.; C/BAYOUMI, M. S. PAA:  
C/(Cairo, University, Cairo, Egypt)  
(American Society of Mechanical Engineers, Energy  
Resources Technology Conference and Exhibition,  
Houston, Tex., Nov. 5-9, 1978.) ASME, Transactions,  
Journal of Energy Resources Technology, vol. 101, June  
1979, p. 145-152.

MAJS: /\*ENERGY CONVERSION EFFICIENCY/\*OPTIMIZATION/\*  
WATERWAVE ENERGY CONVERSION

MINS: / BUOYANCY/ ENERGY TECHNOLOGY/ FLOATS/ GRAPHS (CHARTS)  
/ MATHEMATICAL MODELS/ SYSTEMS ENGINEERING/ WATERWAVE  
ENERGY

ABA: B.J.

ABS: A generalized procedure for the rational selection of  
the design parameters of a simple wave power  
absorption system is presented. The system employs a  
tethered-symmetrical float which rides the seawaves  
and transmits the wave energy to a viscously damped  
load. The optimum load levels corresponding to the  
different sea states are determined for several float  
geometries in order to maximize the overall efficiency  
of wave-power conversion. The optimum float dimensions  
are constrained to guarantee that the float will not  
leave the wave crest during its upward travel or sink  
below the wave trough as it goes downward. The  
procedure also predicts, for different float  
configurations, the limits that, if satisfied, can  
guarantee that the system would operate at its maximum  
possible efficiency irrespective of the wave  
conditions.

SEA-GOING TURBINE HARNESSES WAVE ENERGY.

Machine Design, vol 51, no 16, July 12, 1979, p. 34

80A17134 ISSUE 4 PAGE 625 CATEGORY 44 79/10/00  
9 PAGES UNCLASSIFIED DOCUMENT

UTTL: Waves, currents, tides Problems and prospects

AUTH: A/VOSS, A. PAA: A/(Kernforschungsanlage Juelich  
GmbH, Juelich, West Germany)  
(United Nations University, East-West Center,  
International Institute for Applied Systems Analysis,  
and University of Hawaii, Conference on Non-Fossil  
Fuel and Non-Nuclear Fuel Energy Strategies, Honolulu,  
Hawaii, Jan. 9-12, 1979.) Energy (UK), vol. 4, Oct.  
1979, p. 623-631.

MAJS: /\*ENERGY POLICY/\*OCEAN CURRENTS/\*TECHNOLOGICAL  
FORECASTING/\*TIDEPOWER/\*WATERWAVE ENERGY CONVERSION

MINS: / ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY/  
OCEAN SURFACE

ABA: (Author)

ABS: A quantitative estimation of the energy potential of  
ocean surface waves, ocean currents and tides and a  
review of the techniques for utilizing these renewable  
energy sources, their present state of development and  
their economic and environmental aspects are  
presented. The potential of wave power, which is in  
the order of 1-10 TW, could become a significant  
source of energy in regions of the world with  
favorable wave conditions, such as the United Kingdom  
and Japan. All wave-power schemes investigated today  
are in early stage of development, and require more  
research to become commercially available. The  
prospects for utilizing ocean currents are relatively  
unattractive due to the small resource base and the  
possible environmental effects. Although tidal mills  
have been used since the eleventh century, today only  
one sizable tidal power plant has been built, the 240  
MWe Rance Tidal Power Station in France. The overall  
potential of tidal energy is about 3 TW, but only in  
certain locations of the world do the natural  
conditions promise technical and economic viability.

79A46315 ISSUE 20 PAGE 3787 CATEGORY 44  
79/04/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: An Investigative study of a wave-energy device  
AUTH: A/GUENTHER, D. A.; B/JONES, D.; C/BROWN, D. G.  
PAA: C/(Ohio State University, Columbus, Ohio)  
(University of Illinois and U.S. Department of Energy,  
Midwest Energy Conference, Chicago, Ill., Nov. 19-21,  
1978.) Energy (UK), vol. 4, Apr. 1979, p. 299-306.  
MAJS: /\*ENERGY CONVERSION EFFICIENCY/\*WATERWAVE ENERGY/  
WATERWAVE ENERGY CONVERSION  
MINS: / BUOYANCY/ ENERGY CONVERSION/ ENERGY TECHNOLOGY/  
FLOATS/ FLYWHEELS/ PRODUCT DEVELOPMENT/ PROTOTYPES/  
TABLES (DATA)  
ABA: A.T.

ABS: The methodology and design of an offshore float device to capture power in waves is presented. Results show that a modification of a mechanical cycle can produce a significant energy increase, and a prototype device will be tested to illustrate that wave power can provide significant amounts of energy. The recovery concept presented increases the deliverable energy that can be captured from a buoyant float following the free passage of a wave, accomplished by sequential capture (preloading) and release of the float at critical stages of wave passage. It is concluded that a simple modification of a mechanical cycle can lead to a significant increase in the developed energy, and specifically, preloading a float in the trough of a wave and releasing it to the surface near the wave crest results in a net increase in the energy which may be extracted from a wave.

#### GAS CONCENTRATION CELLS FOR THE CONVERSION OF OCEAN WAVE ENERGY. R. E. Salomon and S. M. Harding.

Ocean Engineering, vol 6, no 3, 1979, p. 317-327.

**Abstract**—The concept of using electrochemical gas concentration cells to convert the mechanical potential energy of ocean waves to electricity using a taut-moored buoy is analyzed. Several idealized embodiments are discussed and one of these is shown to have particular merit. Some results obtained in an experimental program aimed at developing such a system are described. In particular, an electrochemical cell employing the protonically conducting synthetic polymer Nafion, bounded by platinum electrodes, has been studied in a manner which simulates the operation of such a device within a taut-moored buoy subject to ocean waves. It is shown that with some modest engineering advances, this system is indeed capable of converting a significant fraction of ocean wave energy into electricity.

79A45780# ISSUE 20 PAGE 3776 CATEGORY 44  
79/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Waves, salinity gradients and ocean currents - Alternative energy sources  
AUTH: A/MCCORMICK, M. E. PAA: A/(U.S. Naval Academy, Annapolis, Md.)  
In: Ocean thermal energy for the 80's; Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 1. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 2B-1/1 to 2B-1/6.  
MAJS: /\*ENERGY SOURCES/\*OCEAN CURRENTS/\*OCEAN THERMAL ENERGY CONVERSION/\*SALINITY/\*WATER WAVES  
MINS: / ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY/ ENVIRONMENT EFFECTS/ GRADIENTS/ TIDE POWERED GENERATORS

ABA: A.T.  
ABS: Ocean wave, salinity gradients, and ocean current energy conversion techniques are reviewed. Cavity resonator and wave focusing systems of ocean wave energy conversion are considered, emphasizing radiant wave interaction, Fresnel-type focusing, and conversion channeling. The salinity gradient system uses osmosis or electrodialysis for converting the energy of mixing of high saline and low saline waters. Osmotic pressure conversion has the greatest energy potential, but its technology requirements are not yet ready. The reverse electrodialytic technology is available, and unlike osmosis, this method is not site dependent. A 75 MW ducted turbine supported around the periphery by liquid bearings is used to study the environmental effects, hydroelastic stability of the rotor blades and the mooring and anchoring systems in ocean current energy conversion.

79A45822# ISSUE 20 PAGE 3812 CATEGORY 48  
79/00/00 9 PAGES UNCLASSIFIED DOCUMENT

UTTL: Ocean thermal and current velocity data requirements for design of an OTEC plant - An update  
AUTH: A/MOLINARI, R. L. PAA: A/(NOAA, Physical Oceanography Laboratory, Miami, Fla.)  
In: Ocean thermal energy for the 80's; Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 1. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 6A-2/1 to 6A-2/9.  
MAJS: /\*DATA ACQUISITION/\*ELECTRIC POWER PLANTS/\*OCEAN CURRENTS/\*OCEAN THERMAL ENERGY CONVERSION/\*OFFSHORE PLATFORMS/\*WATER TEMPERATURE  
MINS: / CLEAN ENERGY/ ENERGY TECHNOLOGY/ FLOW VELOCITY/ RESOLUTION/ THERMISTORS

79A40198# ISSUE 17 PAGE 3233 CATEGORY 44  
79/06/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: Power extraction from ocean surface waves  
AUTH: A/BROWN, D. G.; B/JONES, D.; C/GUENTHER, D. A.  
PAA: A/(Systems Engineering Associates, Atlanta, Ga.);  
B/(Anow Manufacturing Co., Columbus, Ohio); C/(Ohio  
State University, Columbus, Ohio)  
(American Society of Mechanical Engineers, Energy  
Resources Technology Conference and Exhibition,  
Houston, Tex., Nov. 5-9, 1978.) ASME, Transactions,  
Journal of Energy Resources Technology, vol. 101, June  
1979, p. 141-144.  
MAJS: /\*ENERGY CONVERSION EFFICIENCY/\*WATERWAVE ENERGY  
CONVERSION/\*WATERWAVE POWERED MACHINES  
MINS: / BUOYANCY/ ENERGY TECHNOLOGY/ FLYWHEELS/ GRAPHS  
(CHARTS)/ PERFORMANCE PREDICTION/ PERFORMANCE TESTS/  
SURFACE WAVES/ TABLES (DATA)/ WATERWAVE ENERGY  
ABA: (Author)

ABS: This paper investigates the use of wave power as a  
viable energy source. A novel method for using a float  
to capture the power of waves is proposed, and the  
responses to a modeled sinusoidal wave form are  
analyzed. The responses of the system, determined  
experimentally and analytically, are correlated to  
illustrate that wave power can provide significant  
amounts of energy. The method analyzed, when employed  
on other float devices, increases the energy output of  
the system.

SALT POWER: IS NEPTUNE'S OLE SALT A TIGER IN THE  
TANK? G. S. Wick.

Oceanus, vol 22, no 4, Winter 1979/80, p. 29-37.

Most of the energy in the oceans is bound in  
thermal and chemical forms. Although thermal  
energy is presently commanding the most  
attention, within the past few years another, rather  
unusual, form has received notice. Where rivers  
flow into the ocean a completely untapped source  
of energy exists — represented by a large osmotic  
pressure difference between fresh and salt water. If  
economical ways to tap these salinity gradients  
could be developed, large quantities of energy  
would be available.

80A14837 ISSUE 3 PAGE 421 CATEGORY 44 79/00/00  
6 PAGES UNCLASSIFIED DOCUMENT

UTTL: On the basic dynamics of extracting power from waves  
AUTH: A/PARKS, P. C. PAA: A/(Royal Military College of  
Science, Shrivenham, Wilts., England)  
In: A link between science and applications of  
automatic control; Proceedings of the Seventh  
Triennial World Congress, Helsinki, Finland, June  
12-16, 1978, Volume 2. (AD0-14794 03-63) Oxford and  
New York, Pergamon Press, 1979, p. 1537-1542.  
MAJS: /\*SEA WATER/\*WATERWAVE ENERGY CONVERSION/\*WATERWAVE  
POWERED MACHINES  
MINS: / ENERGY TECHNOLOGY/ EQUATIONS OF MOTION/ LINEAR  
SYSTEMS/ MATHEMATICAL MODELS/ SPRINGS (ELASTIC)/  
STRINGS/ WATERWAYS/ WAVE EQUATIONS  
ABA: C.F.W.

ABS: The paper examines some basic mechanisms for  
extracting power from waves, first from waves on taut  
strings and then from waves in the sea. A  
mathematically attractive device for absorbing power  
from sea waves is proposed in the form of an  
exponentially shaped wedge containing a tuned  
mass-spring system with damping. Attention is given to  
single and double-sided systems; singled-sided systems  
suitably tuned were found to extract all the power  
from an incoming harmonic wave train, while the  
double-sided systems can usually extract only half  
this power.

79A37914 ISSUE 15 PAGE 2794 CATEGORY 44  
79/00/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: Options and constraints in the use of wave power  
AUTH: A/MCILHAGGER, D. S. PAA: A/(Belfast, Queen's  
University, Belfast, Northern Ireland)  
In: International Conference on Future Energy  
Concepts, London, England, January 30-February 1,  
1979, Proceedings. (A79-37842 15-44) London,  
Institution of Electrical Engineers, 1979, p. 390-393.  
MAJS: /\*ELECTRIC POWER/\*ENERGY SOURCES/\*WATERWAVE ENERGY  
CONVERSION  
MINS: / ENERGY STORAGE/ ENERGY TECHNOLOGY/ INDUSTRIAL ENERGY  
/ POWER TRANSMISSION

ABA: B.J.  
ABS: Various aspects of wave energy conversion are reviewed  
with attention given to the storage of wave energy  
(taking into account cyclic, intermittent, and  
seasonal variations) and the compatibility of  
manufacturing processes with wave power supply. Modes  
of wave power transmission (including hydraulic,  
pneumatic, thermal, and chemical) are discussed along  
with modes of generation, transmission, and  
utilization of electric power obtained from the waves.

79A37872 ISSUE 15 PAGE 2791 CATEGORY 44  
79/00/00 7 PAGES UNCLASSIFIED DOCUMENT

UTTL: System reliability studies for wave energy generation  
AUTH: A/DAWSON, J. M.; B/MYTON, M. G.; C/DIN, S.;  
D/SHORE, N. L.; E/STANSFIELD, H. B. PAA: B/(Rendel  
Palmer and Tritton, London, England); E/(Kennedy and  
Donkin, Woking, Surrey, England)  
In: International Conference on Future Energy  
Concepts, London, England, January 30-February 1,  
1979. Proceedings. (A79-37842 15-44) London,  
Institution of Electrical Engineers, 1979, p. 170-176.  
MAJS: /\*RELIABILITY ENGINEERING/\*SYSTEMS ENGINEERING/\*  
WATERWAVE ENERGY CONVERSION  
MINS: / ENERGY TECHNOLOGY/ FAILURE ANALYSIS/ OFFSHORE  
PLATFORMS/ UNITED KINGDOM  
ABA: B.U.  
ABS: A first simplified approach to quantifying reliability  
for each stage of a wave power generation project is  
developed with particular application to United  
Kingdom conditions. The analysis is based on a  
notional scheme with floating devices generating power  
which is transmitted to platforms and thence to the  
shore. The basis of the model is that each component  
in the system always resides in either of two states:  
operative and failed. The system outcome (the power  
delivered via the inverter station) depends on the  
input power and the state of each of the components.  
Preliminary results are presented.

#### THEORETICAL ANALYSES OF SOME SIMPLE WAVE POWER DEVICES. N.A. Tornqvist.

International Journal of Energy Research, vol 2, no 3,  
July-September 1978, p. 281-294.

The problem of how to extract energy from ocean waves is discussed by analysing theoretically the hydrodynamic properties of a few ideal devices, involving vertical energy absorbing plates. The aim is to find a mechanism with high ideal efficiency, but still simple enough, such that its realization in practice can be economically feasible.

The most promising device involves one or more vertical elastic plates situated in the water perpendicular to the incoming waves. About a quarter of a wavelength after the (first) plate there is a stiff vertical construction extending sufficiently deep in the water such that it is rather immobile. It serves as a reflector of the waves. The elastic plate is set in oscillation by the wave motion and this motion is used to extract the energy by applying a braking force. The optimal force field is discussed in some detail, and it is shown that not much of the optimal efficiency is lost by letting the force field simply be proportional to the velocity. The device is also shown to be sensitive to a fairly broad spectrum of wavelengths, and this spectrum can be broadened by adding more swinging plates. In this way efficiencies of 80-100 per cent are attained in theory over a wavelength spectrum extending over an order of magnitude.

79A37864 ISSUE 15 PAGE 2790 CATEGORY 44  
79/00/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: System economic optimisation for wave energy  
AUTH: A/COTTRILL, J. E. J. PAA: A/(Department of Energy,  
London, England)  
International Conference on Future Energy Concepts,  
London, England, January 30-February 1, 1979.  
Proceedings. (A79-37842 15-44) London, Institution of  
Electrical Engineers, 1979, p. 126-129.  
MAJS: /\*ECONOMIC ANALYSIS/\*ENERGY CONVERSION EFFICIENCY/\*  
WATERWAVE ENERGY CONVERSION  
MINS: / ENERGY TECHNOLOGY/ OPTIMIZATION/ SYSTEMS ENGINEERING  
ABA: B.U.  
ABS: It is shown that the annual load factor of a wave  
energy scheme is a function of design rating expressed  
in kW/meter. As design rating is increased more energy  
can be extracted per meter of wave front, but annual  
load factor falls. The optimum load factor is shown to  
depend on the breakdown of costs of the components of  
the system but to be independent of absolute costs. A  
high load factor implies a low energy extraction per  
meter and hence an underutilization of equipment at  
the device end. A low load factor implies high ratings  
and hence an underutilization of equipment at the  
transmission end.

A79-37861 Wave power - Some practical considerations. I.  
Glendenning (Central Electricity Generating Board, Marchwood  
Engineering Laboratories, Marchwood, Surrey, England). In: Interna-  
tional Conference on Future Energy Concepts, London, England,  
January 30-February 1, 1979. Proceedings. (A79-37842 15-44)  
London, Institution of Electrical Engineers, 1979, p. 109-113.

It is suggested that the overall economic viability of wave power  
devices depends as much on operational and maintenance considera-  
tions as on first costs. In this respect the best known and potentially  
the most attractive device, the duck, may be at a severe disadvantage  
when compared with less sophisticated devices. In addition, it is  
shown that the physical scale, peak power rating, and maximum  
continuous rating are independent variables in a complex optimization  
process for identifying the minimum energy production cost  
design. Finally, there is no short cut to the estimation of the energy  
produced by such devices. B.J.



79A37915 ISSUE 15 PAGE 2791 CATEGORY 44  
79/00/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: Electrical generation from a randomly varying input  
--- waterwave energy conversion

AUTH: A/WHITTINGTON, H. W.; B/WILSON, D. S. PAA:  
B/(Edinburgh, University, Edinburgh, Scotland)  
In: International Conference on Future Energy  
Concepts, London, England, January 30-February 1,  
1979. Proceedings. (A79-37842 15-44) London,  
Institution of Electrical Engineers, 1979, p. 402-405.

MAJS: /\*ELECTRIC GENERATORS/\*WATERWAVE ENERGY CONVERSION/\*  
WATERWAVE POWERED MACHINES

MINS: / ENERGY TECHNOLOGY/ PERFORMANCE TESTS/ SYSTEMS  
ENGINEERING

ABA: P.T.H.

ABS: An asynchronous electric generation system based on  
induction generators feeding a common bus bar with  
local provision of quadrature current was developed  
for sea wave power extraction, where the randomly  
varying input makes conventional synchronous  
extraction not viable. A synchronous machine operates  
as a local compensator, providing the magnetizing  
current requirements of the induction generators and  
drawing its own windage and friction losses from the  
induction generators. A 1/200 scale version of the  
system was built and tested with the synchronous  
machine set with (1) a resistive load, and (2) a diode  
load. Ranges of stable operation were determined.

Energy, v.4, no.5

Oct.  
1979

RENEWABLE ENERGY PROSPECTS. (Special issue).  
(Proceedings of a Conference on Non-Fossil Fuel  
and Non-Nuclear Fuel Energy Strategies.  
Held in Honolulu, Hawaii, Jan. 9-12, 1979.  
Sponsored by the United Nations University at  
Tokyo, Japan). Wilfrid Bach, et al, eds.

Voss, A.: Waves, currents, tides—problems and prospects ..... 823  
Jeffs, E. J.: The application potential of hydro power ..... 841

TK  
1457  
R67  
1979

Ross, David.

Energy from the waves / David Ross. --  
Oxford ; New York : Pergamon Press, c1979.  
xvi, 121 p. : ill. -- (Pergamon inter-  
national library of science, technology,  
engineering, and social studies)  
Bibliography: p. 117-118.  
Includes index.  
ISBN 0-08-023271-X  
1. Ocean wave power. 2. Electric  
power produc- tion--Great Britain.  
I. Title.

WAVE ENERGY AND THE ENVIRONMENT. K. Probert and R.  
Mitchell.

NewsScientist, vol 83, no 1166, August 2, 1979, p. 371-  
373.

Hailed as a "clean" and "safe" source of energy, wave  
power devices nevertheless pose their own hazards to  
the environment.

WAVE-TUNED PLATES HARNESS SEA POWER.

David Scott.

Popular Science, col 214, no 5, May 1979, p. 74-75.

A super-efficient design  
that works in the lab is  
readied for the Atlantic

EXPLOITING WAVE POWER.

IEEE Spectrum, vol 16, no 9, September 1979, p. 42-49.

To realize the promise, engineers must deal with unique  
power-transfer modes, erratic seas, and unfavorable  
economics.



**A80-28260 #** Ocean wave energy conversion concepts. M. E. McCormick (U.S. Naval Academy, Annapolis, Md.). In: OCEANS '79; Proceedings of the Fifth Annual Combined Conference, San Diego, Calif., September 17-19, 1979. (A80-28251 10-99) New York, Institute of Electrical and Electronics Engineers, Inc., 1979, p. 553-558, 10 refs.

Nine ocean wave energy conversion techniques are described and discussed. These techniques include the use of heaving and pitching bodies, cavity resonators, wave focusing, pressure devices, surging devices, paddles, outriggers and combination devices. Examples of each technique are presented, and required subsystems are described. Finally a comparison study is performed based on efficiency, operational practicality and cost. (Author)

**A80-28261** Coriolis Program - A review of the status of the ocean turbine energy system. P. B. S. Lissaman and R. L. Radkey (AeroVironment, Inc., Pasadena, Calif.). In: OCEANS '79; Proceedings of the Fifth Annual Combined Conference, San Diego, Calif., September 17-19, 1979. (A80-28251 10-99) New York, Institute of Electrical and Electronics Engineers, Inc., 1979, p. 559-565, 12 refs.

The goal of the Coriolis Program is to develop an energy system to generate electrical power via an array of large ducted turbines moored about 30 km east of Miami in the Florida Current of the Gulf Stream. Numerous studies have been made of the technical, economic, and environmental issues involved. Here, this program background is given, and the system as currently envisaged is described. The Florida Current resource is discussed, using estimates of the power available from the momentum flux. Important environmental issues are reviewed and estimates of effects are given

which show that the program will have no adverse local or global effects. A recent U.S. Department of Energy sponsored study of the hydrodynamic and hydroelastic behavior of key system components is described. In this work, theoretical and experimental studies show that the catenary turbine rotors will be free of adverse vibrations and that the proposed mooring system will be stable and well damped. Finally, the overall Coriolis Program plan is reviewed and the next phases for the design and construction of a small scale (11 m diameter) prototype are discussed. (Author)

**A80-30801** Submerged cylinder wave energy device - Theory and experiment. D. V. Evans (Bristol University, Bristol, England), D. C. Jeffrey, S. H. Salter, and J. R. M. Taylor (Edinburgh University, Edinburgh, Scotland). *Applied Ocean Research*, vol. 1, Jan. 1979, p. 3-12, 11 refs. Research supported by the Science Research Council.

Linearized water wave theory is used to show that a submerged long circular cylinder suitably constrained by springs and dampers to make small harmonic oscillations, can be extremely efficient in absorbing the energy in an incident regular wave whose crests are parallel to the axis of the cylinder. Experimental results are described which confirm the theory for small amplitude waves and which suggest that the device can still be fairly efficient in waves of moderate amplitude. (Author)

**A79-33767** Design and experimental testing of a fully-submerged model wave-power converter. G. F. Knott and J. O. Flower (Sussex University, Brighton, England). *International Journal of Energy Research*, vol. 3, Apr.-June 1979, p. 157-172, 8 refs. Research supported by the Science Research Council.

A new form of wave-power converter is described which operates entirely beneath the water surface. Its operating principles are derived from theories relating to immersed cylinders which predict that a substantial proportion of incident wave-power can be absorbed by such bodies if they are constrained to respond to the waves in a prescribed way. Here, a series of discrete pulsating sources distributed around the surface of a stationary cylindrical body are used to approximate the necessary bodily motion. A one-hundredth scale model has been built and tested in a wave-tank, and the results of these experiments are presented. They indicate that under optimum operating conditions most of the incident wave-power is absorbed by the device. However, little of this power appears as useful work owing to the frictional losses inherent in such a small-scale model. Further analysis of the data estimates the extent of the losses, and after taking these into account figures are arrived at for the optimal operation of the model in loss-less condition. This paper concludes with a discussion of the prospects for further development. (Author)

**N80-19637#** Massachusetts Inst. of Tech. Cambridge. Water Resources and Hydrodynamics Lab.

#### WAVE POWER EXTRACTION BY FLOATING BODIES

C. C. Mei and J. N. Newman. Nov. 1979. 27 p. refs.

(Contract N00014-76-C-0214)

(AD-A078058) Avail: NTIS HC A03/MF A01 CSCL 10/2

The linearized theory of water waves is reviewed in the context of wave-energy absorbers. A global analysis is outlined, leading to relatively simple expressions for the maximum energy absorption. Calculations are presented for the performance of Salter cam in two dimensions, and of a Cockerell raft in both two and three dimensions. Similar rates of optimum energy absorption are anticipated for other devices including the Kaimei ship and French air bag. (Author) (GRA)

**N79-32736#** Office of Technology Assessment, Washington, D. C.

#### RENEWABLE OCEAN ENERGY SOURCES. PART 2: WORKING PAPERS: OCEAN WINDS, CURRENTS, WAVES, TIDES AND SALINITY GRADIENTS

Mar. 1979. 153 p. refs.

(PB-295876/7) Avail: NTIS HC A08/MF A01 CSCL 10B

Renewable ocean energy systems are described. Six ocean energy systems are presented. They are: ocean thermal energy conversion, tidal power generation, ocean winds for windpowered generators, ocean waves for waterwave energy conversion, ocean currents, and salinity gradients. The relative potential for contributing to future energy supplies and the state of advancement are assessed. (Author) AWH

**A79-37858** Directly driven generators for wave energy conversion. R. J. Jackson (Central Electricity Generating Board, Research Laboratories, Leatherhead, Surrey, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979. Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 92-95.

It is found that a directly driven ac generator applied in a wave energy conversion system (a linked pontoon pair wave energy converter) would have high losses (typically 11% of the generator output) and be much larger than the equivalent fixed speed machine. A directly driven homopolar generator would have relatively low losses, less than 5% of the mean power output, but the reversal of the rotor at the wave frequency necessitates the use of carbon brushes which would require regular maintenance. A smart generator which provides a variable reaction torque proportional to the displacement velocity and acceleration of the wave energy converter pontoons will be the same size and have about the same losses as the conventional generator which provides a fixed velocity proportional torque. (B.J.)

**A79-45897** How to measure and optimize the efficiency of a wave power converter. N. A. Tornqvist (Helsinki University, Helsinki, Finland). *International Journal of Energy Research*, vol. 3, July-Sept. 1979, p. 289-295, 6 refs. Research supported by the Academy of Finland.

A method of measuring the hydrodynamic efficiency of a wave power converter that measures both the horizontal and the vertical wave motion is discussed. The problem of adjusting the internal parameter for optimal efficiency, such as the brake force strength, is examined. A mathematical and analytical approach in solving the complex spectral function, using the wave number vector as well as space and time coordinates is presented. It was concluded that there was no visible gain in using a specific mode converter, because for a reasonably narrow spectrum, the theoretical optimal efficiency is already quite high even if statistical averages are used to control the converter. (C.F.W.)

**A79-31099** Two-dimensional analyses related to wave-energy extraction by submerged resonant ducts. J. Lighthill (Cambridge University, Cambridge, England). *Journal of Fluid Mechanics*, vol. 91, Mar. 23, 1979, p. 253-317, 14 refs.

It is pointed out that submerged resonant ducts offer an approach to the design of wave-energy extraction devices consistent with the need for maximum seaworthiness. A full account is provided of one type of analysis of these systems, based upon two-dimensional wave hydrodynamics and linearized duct dynamics. One theoretical prediction is that the effective pressure fluctuations to which a resonant duct responds can be substantially greater than those that would be present at the level of the duct mouth if the duct were absent. Other important predictions are concerned with added mass, radiation damping, and the conditions for optimum energy extraction. (G.R.)

**A79-37918** Energy analysis of wave and tidal power. R. Harrison, K. G. Smith, and J. S. Varley (Sunderland Polytechnic, Sunderland, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 422-426. 12 refs.

A methodology is developed for energy analysis of wave and tidal power based on the concepts of energy ratio defined as total output over lifetime of device divided by energy required to build the device or the output of the device over one year divided by energy requirements for one year's operation, and extraction efficiency, defined as total output of device over a season divided by total energy incident on the devices at that location. When applied to the Salter duck, the energy ratio analysis gives a figure of 13.1 for a duck made of concrete, which implies viability, but a ratio of 10.1 for a steel duck, which is probably not viable. For a Shaw two-basin tidal power system, it is clear that the energy requirement of construction will be a significant fraction of the barrage output, and that further work on energy analysis is justified. P.T.H.

**N80-14576#** Massachusetts Inst. of Tech., Cambridge. Marine Industry Advisory Services.

#### WAVE POWER SYSTEMS

Norman Doelling 1 Jul 1979 33 p refs

(PB-299851/6; MITSG-79/16; NOAA-79080910;

Opportunity-Brief-15) Avail: NTIS HC A03/MF A01 CSCL 10A

Ocean wave power was investigated as a usable, renewable, alternative energy source. The results suggest that both Salter cams and Cockerell rafts can be designed to convert wave motion to relative mechanical motion and mechanical forces. Mooring problems and costs suggest that Salter cams will be much more expensive than Cockerell rafts. A major problem is converting the available mechanical power to a more useful form, i.e., hydraulic or electric power. Upper limits on the amount of power that can be extracted from waves were investigated along with lower cost bounds. GRA

**A79-15908** Ocean energy unlimited. D. D. Woodbridge. In: Energy technology V: Challenges to technology; Proceedings of the Fifth Conference, Washington, D.C., February 27-March 1, 1978. (A79-15879 04-44) Washington, D.C., Government Institutes, Inc., 1978, p. 664-674.

An ocean swell and wave energy converter (OSWEC) is described. The converter utilizes the vertical component of wave or swell motion by means of a 'slinky' coil attached at one end to a stable structure and at the other end to a floating mechanism. Current is generated as the expanding or contracting coil passes through a magnetic field. Energy production obtained from oscillating coil and fixed coil OSWEC systems is determined, and a wave amplification OSWEC system is explained. It is suggested that a 3-megawatt OSWEC be combined with a 1-megawatt solar energy collection system in a 100-m-diameter complex. M.L.

**A79-22223** The oscillating water column wave-energy device. D. V. Evans (Bristol, University, Bristol, England). *Institute of Mathematics and Its Applications, Journal*, vol. 22, Dec. 1978, p. 423-433. 7 refs.

An expression is obtained for the efficiency of wave-energy absorption of a float connected to a spring-dashpot system on the top of a column of fluid bounded by two closely-spaced vertical parallel plates or a narrow tube immersed under waves. The method makes extensive use of the approximate solution using matched asymptotic expansions obtained by Newman (1974) to the corresponding problem when the float-spring-dashpot system was absent. It is shown that for plates of equal length the maximum possible efficiency is 50%, and that for the three-dimensional case it is theoretically possible to capture the energy in a wave whose crest length is greater than the tube diameter. (Author)

**A79-14772 #** Salinity power station at the Swedish west-coast - Possibilities and energy-price for a 200 MW plant. A. T. Emren and S. Bergstrom (Goteborg, Universitet, Goteborg, Sweden). In: Miami International Conference on Alternative Energy Sources, Miami Beach, Fla., December 5-7, 1977, Proceedings of Condensed Papers. (A79-14760 03-44) Coral Gables, Fla., University of Miami, 1978, p. 887-889.

The feasibility of constructing on the west coast of Sweden a 200-MW salinity power plant utilizing electrochemical concentration cells is investigated. Consideration is given to problems associated with plant design, biofouling, plant siting, the environment, and energy costs. B.J.

**A79-50891** Wave power, progress and prospects. B. M. Count (Central Electricity Generating Board, Marchwood Engineering Laboratories, Marchwood, England). In: Conference on Environmental Aspects of Non-Conventional Energy Resources - II, Denver, Colo., September 26-29, 1978, Proceedings. (A79-50876 22-45) La Grange Park, Ill., American Nuclear Society, 1978, p. 31-3 to 31-33. 12 refs.

The environmental acceptability of wave power has been one of the major arguments for proposing it as an alternative source of energy to both nuclear and fossil fuels. From the work described in the present paper, it appears that the deployment of wave power could have a varied impact on the environment. Some of the effects may be beneficial, some adverse, and to argue the case for wave energy on environmental issues alone would certainly be unjustified and misleading. Many of the arguments presented depend crucially on the technical solutions that are likely to be employed. Certain effects, particularly littoral drift, will be device specific, with seabed fixed structures altering the wave climate more than floating ones. Expensive research work is required in view of the formidable technological problems which still exist. V.P.

**A79-40198 #** Power extraction from ocean surface waves. D. G. Brown (Systems Engineering Associates, Atlanta, Ga.), D. Jones (Anow Manufacturing Co., Columbus, Ohio), and D. A. Guenther (Ohio State University, Columbus, Ohio). (American Society of Mechanical Engineers, Energy Resources Technology Conference and Exhibition, Houston, Tex., Nov. 5-9, 1978.) *ASME, Transactions, Journal of Energy Resources Technology*, vol. 101, June 1979, p. 141-144. 12 refs.

This paper investigates the use of wave power as a viable energy source. A novel method for using a float to capture the power of waves is proposed, and the responses to a modeled sinusoidal wave form are analyzed. The responses of the system, determined experimentally and analytically, are correlated to illustrate that wave power can provide significant amounts of energy. The method analyzed, when employed on other float devices, increases the energy output of the system. (Author)

**A78-46069** A resonating transducer for the utilization of sea wave energy. E. Taschdjian. *Energy Communications*, vol. 4, no. 4, 1978, p. 393-404. 5 refs.

A device for the utilization of the energy of sea waves is described, consisting essentially of a narrowing channel, a swimmer, a magnetized lever and a set of transducing wires. The whole arrangement is modeled upon and is analogous to the structure and function of the mammalian ear. It is proposed that the electricity produced, after rectification, be used locally for the electrolysis of sea water. (Author)

**A78-48817** Theoretical analyses of some simple wave power devices. N. A. Tornqvist (Helsinki, University, Helsinki, Finland). *International Journal of Energy Research*, vol. 2, July-Sept. 1978, p. 281-294. 14 refs. Research supported by the Academy of Finland.

A theoretical analysis of the hydrodynamic properties of a few ideal devices which utilize vertical energy-absorbing plates is presented. A proposed system which uses vertical elastic plates perpendicular to incoming waves is described. The system includes a rather immobile wave reflector situated about a quarter of a wavelength behind the first plate. The optimal force field is considered; the spectrum of appropriate wavelengths can be broadened by adding more swinging plates, so that efficiencies of 80-100% are theoretically attainable for a wavelength spectrum extending over an order of magnitude. M.I.

**A79-14773 #** Useful power from ocean waves. M. Semo. In: Miami International Conference on Alternative Energy Sources, Miami Beach, Fla., December 5-7, 1977, Proceedings of Condensed Papers. (A79-14760 03-44) Coral Gables, Fla., University of Miami, 1978, p. 895-902.

Requirements for an ocean-wave power generator are stipulated and a novel concept to meet those requirements, based on submerged pressure transducer system, is described and discussed. A comparison between solar, wind and ocean-wave energy density is given. Calculations for 24 hour periods indicate that ocean-wave energy possesses the highest energy density per unit area - seven times more than solar energy under average conditions. (Author)

UTTL: Integrating wave power into the electricity supply system

AUTH: A/VIMUKTA, D.

CORP: Open Univ., Milton (England). AVAIL NTIS SAP: HC  
A02/MF A01; Secretary, Energy Research Group, Milton  
Keynes, Engl. HCL1.00

MAJS: /ELECTRIC POWER SUPPLIES/ MATHEMATICAL MODELS/ MONTE  
CARLO METHOD/ WATERWAVE ENERGY CONVERSION

MINS: / COST EFFECTIVENESS/ DEMAND (ECONOMICS)/ PERIODIC  
VARIATIONS/ TECHNOLOGY ASSESSMENT

ABA: Author

ABS: As a source of electricity wave power has two distinctive features, one favorable - its good seasonal correlation with demand - and one unfavorable - its unpredictability. Data on wave-power was combined with a previously developed model of seasonal and diurnal variations in electricity supply, using Monte-Carlo methods, to calculate the effect of wave power upon the load-duration curve and hence upon the electricity supply as a whole. It seems from the results that while a small wave power program could usefully have a high power cutoff so as to use the power available in winter storm surges, any program designed to make a substantial contribution to electricity supply would have to concentrate on cheap and reliable delivery of the power available below a quite low cutoff (approximately 25 kW/m).

#### WIND - WAVE POWER AVAILABLE TO A WAVE ENERGY CONVERTER ARRAY.

M. E. McCormick

Ocean Engineering, Vol. 5, No. 2, April 1978, p. 67-74.

**Abstract**—A theoretical expression of the wave power striking a rectilinear array of wave energy conversion devices in a random sea is derived. The theory is then applied to a linear array which is 1 km in length. For purposes of illustration, the Pierson-Neumann-James directional spectrum is used to represent the random sea. Comparison of the results obtained by using the present theory with those obtained from the previously accepted theory shows significant differences. First, the maximum available power predicted by the present theory is 75% of that predicted by the former theory. Secondly, power transmission is predicted when the wind direction and the array axis are parallel, whereas no power transmission was formerly predicted for this condition.

#### ON THE DYNAMICS OF WAVE-POWER DEVICES, by B. M. Count.

Proceedings of the Royal Society of London, vol. 363 no. 1715, November 1978, p.559-579.

The performance of a class of wave-power devices is studied theoretically by generalizing the known theory of ship dynamics with which there is good agreement with experiment. The extensions to the existing theory introduce the new features of asymmetry and articulation common to many proposed wave energy converters.

Results are presented for two different devices and a comparison is made between them. The performance calculations correlate very well with the available experimental evidence and moreover it would appear that the two types of device considered in this paper are comparable in their potential operating efficiencies if appropriate scales are chosen.

The Salter duck and a two-pontoon system, semi-elliptical in cross section and hinged at its centre, constrained to move only in the mode in which energy is absorbed, appear to be equivalent. Both structures are designed such that when forced to move in their absorbing mode they generate waves in one preferred direction, the pontoon design relying on the use of a shallow horizontal breakwater in the rear of the moving structure whereas Salter has used a shorter deeper structure which looks almost cylindrical.

#### THE ISAACS WAVE-ENERGY PUMP: FIELD TESTS OFF THE COAST OF KANEOHE BAY, HAWAII, by Gerald L. Wick and David Castel.

Ocean Engineering, vol. 5, no. 4, August 1978, p.235-242.

**Abstract**—Field tests conducted on a wave-power pump showed that this simple design conceived by Professor John D. Isaacs is suitable for wave-energy extraction around the Hawaiian Islands. In the small model tested, over 200 W of mechanical power were produced. Larger models could extract several orders of magnitude more power. Further research needs to be done with prototype models. The transmission of the power to the shore still needs to be examined.

A by-product of the operation of the pump is nutrient rich water pumped from the bottom of the pipe. In our test, the water was pumped from 300 ft. It is feasible with a similar design that the water can be pumped from 1000 ft where the water is richer in nutrients. This water could then be used to stimulate the growth of marine plants.



79N25532# ISSUE 16 PAGE 2149 CATEGORY 44 RPT#:  
PB-293603/7 MITSG-78-22 NOAA-79030202 CNT#:  
NOAA-04-6-158-44081 78/12/00 80 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: An experimental study and engineering evaluation of  
the salter cam wave energy converter  
AUTH: A/CARMICHAEL, A. D.  
CORP: Massachusetts Inst. of Tech., Cambridge. CSS: (Dept.  
of Ocean Engineering.) AVAIL:NTIS SAP: HC A05/MF  
A01  
MAJS: /\*DIRECT POWER GENERATORS/\*OCEAN CURRENTS/\*WATERWAVE  
ENERGY CONVERSION  
MINS: / CAMS/ COST ANALYSIS/ ELECTRIC GENERATORS/  
HYDRODYNAMICS/ MOORING/ OFFSHORE PLATFORMS  
ABA: GRA  
ABS: The experiments were carried out with a model cam  
placed in a wave channel and in a towing tank. The  
tests in the towing tank were with a floating model to  
simulate ocean conditions. The results indicate that  
the Salter cam was capable of extracting much of the  
energy in regular waves and confirmed Salter's  
findings. From the engineering evaluation it was  
concluded that there are major unsolved problems  
associated mainly with the mooring system. The  
predicted cost of electricity brought to the shore was  
much higher than costs predicted for more conventional  
methods of electrical power production during the  
1990's.

# POWER FROM SALINITY GRADIENTS Gerald L. Wick Energy Vol. 3, no. 1, February 1978, p. 95-100.

Abstract—A large source of energy exists at the interface between water bodies of different salinities. Two techniques, pressure-retarded osmosis and reverse electrodialysis, appear to be promising entrees into this energy source. Although the present cost of membranes suitable to these methods is too high, a research and development effort should make this salinity gradient energy competitive with other energy sources.

## WIND, WAVES AND TIDES.

Engineering, vol. 218, no. 12, December 1978, p.1318-  
1321.

Two symposia were organised by BHRA Fluid Engineering during  
August and September 1978. The first dealt with wave and tidal  
energy, the second with wind-energy systems. This article sum-  
marises some of the work reported at the symposia

79A27389 ISSUE 10 PAGE 1835 CATEGORY 44  
78/00/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: A wave activated electric generator --- waterwave  
energy conversion  
AUTH: A/OMHOLT, T. PAA: A/(Maritime College, Bronx, N.Y.)  
In: Oceans '78: The ocean challenge: Proceedings of  
the Fourth Annual Combined Conference, Washington,  
D.C., September 6-8, 1978. (A79-27376 10-48)  
Washington, D.C., Marine Technology Society: New York,  
Institute of Electrical and Electronics Engineers,  
Inc., 1978, p. 585-589.  
MAJS: /\*ELECTRIC GENERATORS/\*OCEAN SURFACE/\*OFFSHORE ENERGY  
SOURCES/\*WATERWAVE ENERGY CONVERSION  
MINS: / BUOYS/ CLEAN ENERGY/ ENERGY CONVERSION EFFICIENCY/  
ENERGY TECHNOLOGY  
ABA: (Author)  
ABS: A large number of devices have been proposed for  
extracting energy from ocean surface waves. This paper  
proposes yet another which operates on the same  
principles as alternating current generators. The  
device forms a two degree of freedom mechanical system  
producing power by electro-magnetic induction. The  
equations governing the system's motion, as well as,  
the rate of power generation is presented. These are  
solved in a special case, which for a typical set of  
operating conditions, lead to energy extraction from  
the waves of 35 percent.

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Offshore and underground power plants.  
Robert Noyes, Ed.  
Noyes Data Corp. 1977.

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78A33327# ISSUE 13 PAGE 2394 CATEGORY 44  
77/00/00 9 PAGES UNCLASSIFIED DOCUMENT

UTTL: Cold water transport, cold water pipe, and deep water mooring line analysis - A parametric approach - for Ocean Thermal Energy Conversion  
AUTH: A/LITTLE, T. E. PAA: A/(Westinghouse Electric Corp., Annapolis, Md.)  
In: Annual Conference on Ocean Thermal Energy Conversion, 4th, New Orleans, La., March 22-24, 1977. Proceedings. (A78-33301 13-44) New Orleans, University of New Orleans, 1977, p. V-40 to V-48.  
MAJS: /\*COLD WATER/\*MOORING/\*OCEAN CURRENTS/\*OCEAN THERMAL ENERGY CONVERSION/\*OFFSHORE ENERGY SOURCES/\*PIPES (TUBES)  
MINS: / CONCRETES/ COST ANALYSIS/ ENERGY TECHNOLOGY/ GLASS FIBER REINFORCED PLASTICS/ OFFSHORE PLATFORMS/ PRESTRESSING/ STEELS  
ABA: (Author)  
ABS: The successful implementation of the ocean thermal power plant is dependent upon the technical and economic feasibility of transporting large volumes of cold water from sea depths of 500 meters or more, through suitable ducting to the power plant condensers. In addition, plant/platform station keeping must be provided by a mooring arrangement and/or by use of dynamic positioning. Highlights of the analysis and evaluation of the cold water transport, cold water pipe, and deep water mooring lines are provided with a view toward judging the impact of these subsystems on the overall OTEC plant/platform concept and to provide an estimate of material and construction cost. Selected parameters, issues, and evaluation criteria are used to assess the merits of candidate subsystems over a range of plant size from 100 MWe to 1000 MWe net output power.

TN  
871.3  
.044

Offshore and underground power plants.  
Robert Noyes, Ed.  
Noyes Data Corp. 1977.

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78A10655 ISSUE 1 PAGE 43 CATEGORY 44 CNT#:  
WA-76-3104 77/00/00 25 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Energy from ocean surface waves  
AUTH: A/PANICKER, N. N. PAA: A/(Mobil Research and Development Corp., Dallas, Tex.)  
In: Ocean energy resources; Proceedings of the Energy Technology Conference, Houston, Tex., September 18-23, 1977. (A78-10651 01-44) New York, American Society of Mechanical Engineers, 1977, p. 43-67.  
MAJS: /\*OCEAN SURFACE/\*SURFACE WAVES/\*WATERWAVE ENERGY CONVERSION  
MINS: / BUOYS/ ELECTRIC POWER PLANTS/ ENERGY DISTRIBUTION/ ENERGY TECHNOLOGY/ FEASIBILITY ANALYSIS/ HYDROELECTRIC POWER STATIONS/ METEOROLOGICAL PARAMETERS/ NORTHERN HEMISPHERE  
ABA: (Author)  
ABS: A quantitative estimation of the energy present in ocean waves, and a review of the techniques for utilizing wave energy are presented. Computations based on climatological data for the Northern Hemisphere show that wave energy is maximum at mid-latitudes and at longitudes towards the Eastern end of the Atlantic and Pacific Ocean basins. The total wave energy present in the world oceans at 12 noon GMT on October 2, 1975 is found to be  $800 \times 10$  to the 15th power J. Wave energy is estimated to be renewed at the rate of 10 to the 12th to 10 to the 13th power watts, about the present level of world power consumption. The techniques for converting wave energy for use vary widely in scope. The proposed schemes include propulsion schemes, buoy power supply devices, offshore power plants and shore-based power stations. The technical and economic feasibility of utilizing wave energy is discussed.

(AD-D-003484) Double-action turbogenerator, McCormick, M.E.; Holt, R.L.; Bosworth, C.E. (Environmental Protection Agency, Denver, Colo. (USA)). 11 Nov 1976. 12p. NTIS, PC A02/MF A01.

Patent application PAT-CL-60-62.

A double-action turbogenerator for providing energy using sinusoidal energy produced by ocean waves is proposed. First and second turbines are mounted on a common shaft and positioned in separate horizontal tubes. An air chamber, which is subjected to ocean waves, alternately applies pressure to one horizontal tube and then a vacuum to the other horizontal tube to drive the turbines. A pair of ratchet joints are provided to prevent the outputs of the two turbines from acting against one another. (Author)



# WAVE POWER TAPPED BY NODDING DUCKS

David Scott

Popular Science

Vol. 211, no. 5, November 1977,

p. 16-18.

The energy in a one-meter wave front off Great Britain's Atlantic coast could supply the electric-power needs of 12 homes. A one-kilometer front could deliver enough power for a town of 85,000. But how can this vast, clean, abundant energy be harnessed?

One promising answer, put forth by Andrew Salter, of Scotland's Edinburgh University, uses shaft-pivoted, cam-shaped floats to drive hydraulic pumps. They're called "noddling ducks" because of their birdlike profile and the way they bob in the waves [PS, May '75, p. 68].

## 13317 WAVE PUMP: WAVE ENERGY TO CURRENT ENERGY

KEY WORDS: Breaking; Energy conversion; Pumps; Wave action; Wave energy; Wave propagation; Waves

ABSTRACT: The Wave Pump converts wave energy to current energy utilizing the momentum of waves which are close to or at the breaking stage. To improve the efficiency of the Pump so that even smaller waves become effective, waves are concentrated in a funnel. Funnel geometry therefore is an important parameter. So is the wave height over depth ratio. The effectiveness of the pump is not reduced even if the direction of wave propagation deviates  $\pm$  approx. 10° from the centerline of the pump. The efficiency of the pump may be further improved by the installation of a ramp at the entrance to the discharge channel. The pump has been thoroughly tested by hydraulic model tests. The first prototype was built at the Palmas Del Mar marina on Puerto Rico as a flushing device in a low tidal range area. It has been in operation for approx. 2 yr. The pump is also useful for flushing of ice in arctic waters. It may be used as an energy producing device on a modest scale.

REFERENCE: Bruun, Per Moller, and Viggoisson, Gisli, "The Wave Pump: Conversion of Wave Energy to Current Energy," *Journal of the Waterway, Port, Coastal and Ocean Division*, ASCE, Vol. 103, No. WW4, Proc. Paper 13317, November, 1977, pp. 449-469

A77-49348

Ocean wave power. I. Glendenning (Central Electricity Generating Board, Marchwood Engineering Laboratories, Southampton, England). *Applied Energy*, vol. 3, July 1977, p. 197-222. 31 refs.

The potential of wave power and some of the more promising methods of harnessing it are discussed with attention to the wave energy arriving on the west coast of the United Kingdom. Unresolved technical and engineering problems are examined, and the impact of wave power on the environment is considered. Data on wave power and its variability are supplied. It is suggested that wave power could be exploited to conserve fossil fuels but is unlikely to be competitive with nuclear power.

M.L.

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1977  
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Canadian Congress of Applied Mechanics,  
6th, University of British Columbia, 1977.  
CNCAM 77; proceedings = Comptes rendus  
/ V. J. Modi, editor. -- [s.l. : s.n.,  
1977?]

2 v. (xli, 1051 p.) : ill. ; 28 cm.  
Held May 30 to June 3, 1977.

Includes bibliographical references.

1. Mechanics, Applied--Congresses. I.  
Modi, V. J. II. Title.

Ocean Wave Power Converters

C. W. Snoek, K. C. Watts . . . 735

N78-21808/ Open Univ., Milton (England).

## INTEGRATING WAVE POWER INTO THE ELECTRICITY SUPPLY SYSTEM

Deus Vimukta Dec. 1977 17 p. refs  
(RR-20) Avail: NTIS HC A02/MF A01; Secretary, Energy  
Research Group, Milton Keynes, Engl. HC £1.00

As a source of electricity wave power has two distinctive features, one favorable - its good seasonal correlation with demand - and one unfavorable - its unpredictability. Data on wave-power was combined with a previously developed model of seasonal and diurnal variations in electricity supply, using Monte-Carlo methods, to calculate the effect of wave power upon the load-duration curve and hence upon the electricity supply as a whole. It seems from the results that while a small wave power program could usefully have a high power cutoff so as to use the power available in winter storm surges, any program designed to make a substantial contribution to electricity supply would have to concentrate on cheap and reliable delivery of the power available below a quite low cutoff (approximately 25 kW/m).

Author

Wave power. Glendenning, I.; Count, B.M. (Central Electricity Generating Board, Southampton, Eng.). *Chem. Eng. (London)*; No. 313, 595-600, 604(Sep 1976).

From Royal Society of Arts symposium on renewable sources of energy; London, England (16 Jun 1976).

Characteristics of the power available from ocean waves are reviewed. Various wave energy converter devices are also described. The feasibility of a wave power system in the United Kingdom is discussed.

77A26091 ISSUE 10 PAGE 1672 CATEGORY 44  
76/00/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: Harnessing the ocean waves, swells and tides

AUTH: A/DERVY, A. J.

In: Energy LA: Tackling the crisis: Proceedings of the  
Second Greater Los Angeles Area Energy Symposium, Los  
Angeles, Calif., May 19, 1976. (A77-26076 10-44) North  
Hollywood, Calif., Western Periodicals Co., 1976, p.  
250-253.

MAJS: /\*ENERGY TECHNOLOGY/\*TIDE POWERED GENERATORS/\*  
WATERWAVE ENERGY CONVERSION

MINS: / COST ANALYSIS/ ENERGY STORAGE/ FLYWHEELS

ABA: B.J.

ABS: The feasibility of obtaining electric power from ocean  
disturbances such as waves, swells, and tides is  
examined. A basic conversion system of the double  
acting type (i.e., both the upward and downward  
motions of the barge are converted into energy) is  
described. A mathematical treatment of the motions is  
presented, and some cost estimates are given.

## OCEAN - THERMAL GRADIENTS

79A51976# ISSUE 23 PAGE 4385 CATEGORY 44 CNT#:  
EG-77-C-01-4042 79/00/00 5 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Solar thermoelectric energy conversion  
AUTH: A/BENSON, D. K.; B/JAYADEV, T. S. PAA: B/(Solar  
Energy Research Institute, Golden, Colo.)  
In: Intersociety Energy Conversion Engineering  
Conference, 14th, Boston, Mass., August 5-10, 1979.  
Proceedings, Volume 2. (A79-51726 23-44) Washington,  
D.C., American Chemical Society, 1979, p. 1825-1829.  
MAJS: /\*OCEAN THERMAL ENERGY CONVERSION/\*SOLAR ENERGY  
CONVERSION/\*SOLAR PONDS (HEAT STORAGE)/\*THERMOELECTRIC  
GENERATORS

MINS: / CLEAN ENERGY/ ENERGY TECHNOLOGY/ IRRIGATION/  
TECHNOLOGY UTILIZATION

ABA: (Author)

ABS: The use of thermoelectric energy conversion for solar  
applications is reexamined in the light of recent  
improvements in thermoelectric materials and the  
possible coupling to economical solar collectors.  
Solar thermoelectric energy conversion is shown to  
have several technical and possible economic  
advantages in applications which make use of low cost  
solar collectors with inherent thermal storage such as  
solar ponds and ocean thermal gradients. The technical  
advantages include system simplicity, modularity,  
mass-producibility, long-life, high reliability, and  
low maintenance requirements. Correlary economic  
advantages include the potential low cost of  
mass-production, low fixed charge rate (assuming  
long-term depreciation), high availability factor, and  
low operation and maintenance costs. Two particular  
applications are discussed - an agricultural  
irrigation system using a solar pond collector and  
thermoelectric powered pump, and a large, base load  
ocean thermal energy conversion system using  
thermoelectric converters. Preliminary cost estimates  
indicate that such applications may be economical.

79A45793# ISSUE 20 PAGE 3778 CATEGORY 44  
79/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Performance optimization of an OTEC turbine  
AUTH: A/VINCENI, S. P.; B/KOSTORS, C. H. PAA: A/(TRW  
Defense and Space Systems Group, Redondo Beach,  
Calif.); B/(Elliott Co., Jeannette, Pa.)  
In: Ocean thermal energy for the 80's; Ocean Thermal  
Energy Conversion Conference, 6th, Washington, D.C.,  
June 19-22, 1979, Preprints, Volume 1. (A79-45776  
20-44) Laurel, Md., Johns Hopkins University, 1979, p.  
4A-3/1 to 4A-3/6.

MAJS: /\*AMMONIA/\*ENERGY CONVERSION EFFICIENCY/\*OCEAN THERMAL  
ENERGY CONVERSION/\*POWER EFFICIENCY/\*TURBOGENERATORS

MINS: / AXIAL FLOW/ CASCADE FLOW/ DESIGN ANALYSIS/ ECONOMIC  
FACTORS/ INLET FLOW/ OPTIMIZATION/ ROTOR BLADES  
(TURBOMACHINERY)

ABA: (Author)

ABS: The need for an ammonia turbine with maximized  
efficiency over the expected range of operation was  
determined during OTEC 10 MWe net power system  
optimization studies. It was determined that for every  
extra KW produced it was worth expending \$1,000 in  
plant cost. Specific application of state-of-the-art  
hardware designs were used to assure that the  
efficiencies determined were realizable. The turbine  
aerodynamic design considered axial flow and radial  
inflow turbines, single and double flow designs, and  
variations in the number of stages and base diameters.  
Consideration was given to the turbine-generator  
control scheme and specific areas of the turbine  
mechanical design such as the blades, seals and  
bearings. The optimum design is a four-stage axial  
flow double flow turbine directly connected to a four  
pole 60 hertz synchronous generator. The efficiency of  
the double-flow, four stage design is more than two  
percent higher than a one-stage, single flow design  
with diffuser. This is due to the latter's inherent  
very high exit velocity. Additional optimally designed  
stages can more efficiently recover this energy than a  
diffuser. Variable nozzles for the first stage are  
utilized for power maximization at off-nominal  
conditions.



79A51759 ISSUE 23 PAGE 4369 CATEGORY 44 CNT#:  
EG-77-C-05-1473 79/00/00 8 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: An open cycle approach to ocean thermal energy conversion

AUTH: A/RITLAND, P. D.; B/COFFAY, B. PAA: B/(Westinghouse Electric Corp., Steam Turbine-Generator Technical Operations Div., Lester, Pa.)

In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979. Proceedings, Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 195-202.

MAJS: /\*ELECTRIC POWER PLANTS/\*OCEAN THERMAL ENERGY CONVERSION/\*THERMODYNAMIC CYCLES

MINS: / CONDENSERS/ DESIGN ANALYSIS/ ECONOMIC FACTORS/ ENERGY TECHNOLOGY/ HEAT EXCHANGERS/ TEMPERATURE GRADIENTS/ TURBOGENERATORS

ABA: (Author)

ABS: A design for an open cycle 100 MW electric net ocean thermal energy conversion plant is described. In this system flashed seawater is used as the working fluid without resorting to an intermediate working fluid as is used in the closed cycle power system options. The design makes use of an ocean platform as integral part of the power system. A large diameter, low speed turbine with lightweight blades is used. The large quantities of noncondensibles require a special approach to the design of condenser and venting systems. The use of either direct contact or surface condensers is possible with a potential of fresh water production with the use of surface condensers. Attention is paid to hull stability to allow the use of barometric principles for fluid handling. The design, economic, and institutional issues relevant to commercialization are also discussed.

**THERMOCLINES: A SOLAR THERMAL ENERGY RESOURCE FOR ENHANCED HYDROELECTRIC POWER PRODUCTION, by**

J. L. McNichols, and W. S. Ginell.

Science, vol. 203, no. 4376, January 1979, p. 167-168.

*Abstract. The solar thermal energy stored in hydroelectric reservoir thermoclines is very large and greatly exceeds the gravitational hydroenergy of the surface water, even after limitations arising from the second law of thermodynamics have been taken into account. Greatly enhanced power production can be obtained at present hydroelectric facilities if heat engines are adapted to exploit this large thermal energy resource.*

BOA17135 ISSUE 4 PAGE 625 CATEGORY 44 79/10/00  
8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Ocean thermal energy conversion /OTEC/ - Social and environmental issues

AUTH: A/LAVI, A.; B/LAVI, G. H. PAA: A/(Carnegie-Mellon University, Pittsburgh, Pa.); B/(ERDI, Inc., Pittsburgh, Pa.)  
(United Nations University, East-West Center, International Institute for Applied Systems Analysis, and University of Hawaii, Conference on Non-Fossil Fuel and Non-Nuclear Fuel Energy Strategies, Honolulu, Hawaii, Jan. 9-12, 1979.) Energy (UK), vol. 4, Oct. 1979, p. 833-840.

MAJS: /\*CLEAN ENERGY/\*ENERGY TECHNOLOGY/\*ENVIRONMENT EFFECTS /\*OCEAN THERMAL ENERGY CONVERSION/\*SOCIAL FACTORS

MINS: / ECONOMIC FACTORS/ GOVERNMENT/INDUSTRY RELATIONS/ INTERNATIONAL TRADE/ ISLANDS/ JAPAN/ UNITED STATES OF AMERICA

ABA: A.L.W.

ABS: Economic, social and environmental issues in the commercialization of OTEC are addressed, assuming technical feasibility and cost competitiveness, at least in certain areas. The market potential of OTEC on U.S. islands and in near-shore regions of the mainland is assessed and the economics of commercialization are considered. It is concluded that the private ownership of OTEC plants and facilities is not likely without government financial incentives, and the nature of possible incentives is outlined. Environmental problems of OTEC are discussed, noting ocean water mixing, chemical leakages, CO2 release from deep cold water and the presence of large numbers of plants and electric cables, and institutional questions of baseload OTEC plant licensing, regulation, world market impact and labor requirements are considered. It is concluded that OTEC represents a beneficial long-term option.

**IS THERE A CHANCE FOR OTEC?, Gordon L. Dugger**

Astronautics & Aeronautics, v.17, no.11, Nov. 1979, p.36-72

Steady growth of the technology, the design plans for pilot plants, and industrial readiness all argue the field verges on a breakthrough.

79A45831# ISSUE 20 PAGE 3780 CATEGORY 44  
79/00/00 13 PAGES UNCLASSIFIED DOCUMENT

UTTL: OTEC 100-MWe alternate power systems study

AUTH: A/RABAS, T. J.; B/WITTIG, J. M.; C/FINSTERWALDER, K.  
PAA: B/(Westinghouse Electric Corp., Steam Turbine  
Generator Technical Operations Div., Lester, Pa.);  
C/(Dyckerhoff and Widmann, Inc., New York, N.Y.)  
In: Ocean thermal energy for the 80's; Ocean Thermal  
Energy Conversion Conference, 6th, Washington, D.C.,  
June 19-22, 1979. Preprints, Volume 1. (A79-45776  
20-44) Laurel, Md.: Johns Hopkins University, 1979, p.  
7C-1/1 to 7C-1/13.

MAJS: /\*ELECTRIC POWER PLANTS/\*OCEAN THERMAL ENERGY  
CONVERSION/\*THERMODYNAMIC CYCLES

MINS: / AMMONIA/ COST ANALYSIS/ ENERGY CONVERSION EFFICIENCY  
/ ENERGY TECHNOLOGY/ HEAT EXCHANGERS/ SYSTEMS  
ENGINEERING

ABA: A.T.

ABS: The results of cost studies for the open and hybrid  
OTEC cycles are summarized and cost comparison between  
these cycles and the previously analyzed closed cycle  
is presented. The major result of these studies is  
that the open cycle OTEC power systems are feasible  
and have a lower capital cost than the ammonia closed  
cycle system, and that the hybrid power system is not  
cost effective. The high steam turbine cost of the  
open cycle system was solved with fiberglass blades  
and a fabricated disk, and the removal of large  
quantities of dissolved gases in seawater was resolved  
by the use of high efficiency axial compressors and  
intermediate after-condensers. The open cycles have  
advantages of reduced biofouling and corrosion and the  
commercial potential of water production. Existing  
multistage flash evaporator saline water conversion  
technology is the basis for the open cycle flash  
chamber design, and the resulting power module designs  
are single vacuum housings containing all components.

## OCEAN THERMAL ENERGY FOR THE 80'S.

Gordon L. Dugger.

AIAA Student Journal, vol 17, no 2, Summer 1979.  
p. 14-19.

*Seventy-one percent of the earth's surface is covered by water. This article  
presents an in-depth look at present and future plans to harness a powerful  
source of energy: ocean waves and currents.*

80A20424 ISSUE 6 CATEGORY 44 79/11/00 27 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: OTEC - Solar energy from the sea

AUTH: A/DOUGLASS, R. H., JR. PAA: A/ITW Defense and Space  
Systems Group, Systems Engineering and Integration  
Div., Redondo Beach, Calif.)  
Quest, vol. 3, Autumn 1979, p. 3-29.

MAJS: /\*ELECTRIC POWER PLANTS/\*OCEAN THERMAL ENERGY  
CONVERSION/\*RANKINE CYCLE/\*SEA WATER/\*SOLAR ENERGY  
CONVERSION/\*SYSTEMS ENGINEERING

MINS: / COLD WATER/ ENERGY TECHNOLOGY/ HAWAII/ HEAT  
EXCHANGERS/ OCEAN SURFACE/ OPTIMIZATION/ SURFACE  
TEMPERATURE/ SYSTEM EFFECTIVENESS/ TURBINE PUMPS/  
TURBOGENERATORS/ WATER TEMPERATURE

ABA: J.P.B.

ABS: The principles and history of ocean thermal energy  
conversion (OTEC) are discussed, along with U.S. and  
foreign OTEC programs, where all proposed OTEC plants  
use the Rankine cycle. Particular attention is given  
to OTEC components such as the mechanically durable  
0.030 inch thick tube walls of the heat exchanger. The  
working fluid of modern closed cycle systems is  
ammonia, and mechanical cleaning and chlorination are  
used against biofouling. Heat exchanger types,  
including shell-and-tube, plate-fin, and trombone are  
considered, as well as the hull of the plant, its  
platform, sea water pumps, and differently designed  
cold water pipes. Moreover, computer models designed  
to study performance sensitivity to various operating  
parameters are discussed.

80N13696# ISSUE 4 PAGE 505 CATEGORY 44 RPT#:  
CONF-790444-2 CNT#: W-31-109-ENG-3B 79/00/00 14  
PAGES UNCLASSIFIED DOCUMENT

UTTL: OTEC power systems

CORP: Argonne National Lab., Ill. AVAIL. NTIS SAP: HC  
A02/WF A01  
Presented at Offshore Technol. Conf., Houston, Tex.,  
30 Apr. 1979

MAJS: /\*ENERGY POLICY/\*ENERGY TECHNOLOGY/\*OCEAN THERMAL  
ENERGY CONVERSION

MINS: / COST REDUCTION/ POLLUTION CONTROL/ TUBE HEAT  
EXCHANGERS

ABA: DOE

ABS: The technical features of design studies of power  
systems using shell and tube heat exchangers and  
shell-less heat exchangers are presented. Heat  
exchanger design, biofouling control, rotating  
equipment, auxiliaries, plant layout, and system cost  
are among the areas discussed. The role of the power  
systems development program in the larger OTEC program  
is also discussed.



79A45871# ISSUE 20 PAGE 3784 CATEGORY 44 CNT#:  
W-7405-ENG-26 79/00/00 6 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Land-based application of an OTEC open-cycle power system

AUTH: A/CHEN, F. C. PAA: A/(Oak Ridge National Laboratory, Oak Ridge, Tenn.)  
In: Ocean thermal energy for the 80's: Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 2. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 8C-4/1 to 8C-4/6.

MAJS: /\*ELECTRIC POWER PLANTS/\*HEAT TRANSFER/\*OCEAN THERMAL ENERGY CONVERSION/\*THERMODYNAMIC CYCLES/\* TURBOGENERATORS

MINS: / CLOSED CYCLES/ COST EFFECTIVENESS/ ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY/ HEAT EXCHANGERS/ HEAT SOURCES/ STEAM TURBINES

ABA: V.P.

ABS: OTEC power system technology, although primarily developed for the utilization of renewable ocean thermal sources, could conceivably also be applied to other types of low-temperature heat sources. For utilizing rejected heat from large thermal power plants, application of open-cycle steam turbine technology to additional very low pressure turbine stages as an integral part of the thermal power plant appears to be more cost effective than a separate bottoming cycle system, where OTEC range cold water is economically available. For utilizing rejected heat for power generation from nuclear facilities, the open cycle has the advantage of not requiring isolation heat exchangers to avoid cross contamination of GDP cooling water. A conceptual thermal analysis of such open-cycle power systems is presented in the present paper.

L'ENERGIE THERMIQUE DES MERS. Phillippe Marchand

LA Recherche, vol. 10, November 1979, p. 1078 - 1089.

English title: Ocean Thermal Energy

An idea first proposed in France takes shape again with the energy problem: electricity can be produced by pumping sea-water.

79A45834# ISSUE 20 PAGE 3795 CATEGORY 45 CNT#:  
EG-77-C-06-1033 79/00/00 4 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: A review of the biological information relating to OTEC operation --- ocean plant and animal life impact

AUTH: A/SULLIVAN, S. M. PAA: A/(Interstate Electronics Corp., Anaheim, Calif.)  
In: Ocean thermal energy for the 80's: Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 1. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 7D-1/1 to 7D-1/4.

MAJS: /\*COASTAL ECOLOGY/\*ENVIRONMENT EFFECTS/\*OCEAN THERMAL ENERGY CONVERSION/\*PELAGIC ZONE/\*WATER POLLUTION

MINS: / CEPHALOPODS/ FISHES/ PLANKTON/ THERMAL POLLUTION/ TROPICAL REGIONS

ABA: V.P.

ABS: The installation and operation of an OTEC power plant may result in such environmental impacts as entrainment of plankton, impingement of organisms on the intake screens, and release of biocides used for fouling control. Conversely, schooling fish and large planktonic organisms may seriously impair the operation of the plant by clogging the intake screens. In the present paper, available information on zooplankton and micronekton is reviewed for three potential OTEC resource areas. A comparison of the biological information at these sites is made, and some site similarities are pointed out. The life history, behavior, density, and spatial distribution of the organisms is discussed in terms of how the plant and the biota may interact. Suggestions to complete the site characterization are given.

BON13635# ISSUE 4 PAGE 498 CATEGORY 44 RPT#:  
SERI/TP-35-300 CONF-7906B5-1 CNT#: EG 77 C-01 4042  
79/06/00 22 PAGES UNCLASSIFIED DOCUMENT

UTTL: Solar energy perspectives for public power

AUTH: A/WOODLEY, N. H.

CORP: Midwest Research Inst., Golden, Colo. AVAIL: NTIS

SAP: HC A02/MF A01

Presented at Am. Public Power Assoc., 1979 Natl. Conf., Seattle, 19 Jun. 1979

MAJS: /\*CONVERSION/\*SOLAR ENERGY/\*SOLAR HEATING/\*TECHNOLOGY ASSESSMENT

MINS: / BIOMASS ENERGY PRODUCTION/ ELECTRIC POWER/ ENERGY TECHNOLOGY

ABA: DOE

ABS: Perspectives on the utilization of solar energy for electricity production and thermal energy utilization by the public are briefly summarized. Wind energy conversion, biomass conversion, solar thermal, OTEC, photovoltaics, and solar heating and cooling are discussed.

BON15664# ISSUE 6 PAGE 770 CATEGORY 45 RPT#:  
CONF-790631-11 CNT#: W-31-109-ENG-38 79/00/00 10  
PAGES UNCLASSIFIED DOCUMENT

UTTL: OTEC physical and climatic environmental impacts

AUTH: A/DITMARS, J. D.; B/PAUDOCK, R. A.

CORP: Argonne National Lab., Ill. CSS: (Energy and  
Environmental Systems Div.) AVAIL:NTIS SAP: HC  
A02/MF A01

Presented at OTEC Conf., Washington, D.C., 19 Jun.  
1979

MAJS: /\*CLIMATE/\*ENVIRONMENT EFFECTS/\*OCEAN THERMAL ENERGY  
CONVERSION

MINS: / AIR WATER INTERACTIONS/ CARBON DIOXIDE CONCENTRATION  
/ GULF OF MEXICO/ OCEAN MODELS/ PLUMES

ABA: DOE

ABS: The Department of Energy program for the development  
and application of analyses and models for the  
prediction of the physical aspects of OTEC impacts is  
reviewed. The effects of intake/discharge designs and  
of ambient ocean conditions on recirculation and near  
field effluent plume behavior were investigated by  
means of physical models. Further study of the intake  
flow fields may be necessary to make estimates of  
intake impingement and entrainment effects.  
Mathematical analysis of intermediate field mixing of  
plant effluents showed that effluent plumes may have  
vertical dimensions on the order of meters and lateral  
dimensions on the order of kilometers. Basin-wide  
resource renewal and physical environmental effects  
are being studied by means of a numerical model of the  
Gulf of Mexico with detailed vertical resolution.  
Concerns regarding climatic impacts presently are  
focused on atmospheric CO2 loading and modification of  
air-sea heat exchange processes due to OTEC operation.

**N79-32627** Carnegie-Mellon Univ., Pittsburgh, Pa.  
**DYNAMIC MODELING, SIMULATION AND CONTROL OF  
OCEAN THERMAL ENERGY CONVERSION POWER PLANTS**  
Ph.D. Thesis

Steven Alexander Heteyi 1979 173 p.  
Avail: Univ. Microfilms Order No. 7919144

Analytical models for major ocean thermal energy conversion  
(OTEC) plant components were derived. Steady-state operating  
conditions for the plant were established using the nonlinear  
algebraic models. The differential equations were linearized about  
the steady-state operating point. Small signal analysis was carried  
out by perturbing each input and observing the resultant system  
outputs. Linear controllers were then proposed to maintain  
regulation within specified range for the key output variables:  
generator frequency and voltage. The same linear controller was  
then applied to the nonlinear plant model. Computer results of  
the simulation of a 1 MWe OTEC system are presented and  
discussed for various control strategies including: (1) speed control  
on the water pumps; (2) bypass shunting of the turbine feed;  
and (3) control of the evaporator heat transfer coefficient.

Dissert. Abstr.

BON15621# ISSUE 6 PAGE 765 CATEGORY 44 RPT#:  
DOE/EDP-0034 79/08/00 53 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Environmental development plan ocean thermal energy  
conversion

CORP: Department of Energy, Washington, D. C. AVAIL:NTIS  
SAP: HC A04/MF A01

MAJS: /\*ENERGY POLICY/\*ENVIRONMENT PROTECTION/\*OCEAN THERMAL  
ENERGY CONVERSION/\*PROJECT PLANNING

MINS: / ECOLOGY/ OFFSHORE PLATFORMS/ PROJECT MANAGEMENT/  
WATER POLLUTION

ABA: DOE

ABS: The present status and goals of the OTEC program are  
described, and potential environmental, health,  
safety, and sociological-economic impacts relevant to  
the program are identified. A management plan is  
presented for conducting and coordinating  
environmental research in concert with the development  
of appropriate technology. Five major classes of  
environmental concerns associated with the deployment  
and operation of an OTEC system are discussed. They  
are changes in oceanic properties, chemical pollution,  
operation of a manned platform, legal and  
institutional matters, and secondary impacts  
associated with site selection, construction, and  
operation of OTEC plants.

BON11938# ISSUE 2 PAGE 265 CATEGORY 77 RPT#:  
CONF-790459-2 CNT#: W-7405-ENG-26 79/00/00 6  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Thermodynamic assessment of OTEC open-cycle power  
systems

AUTH: A/CHEN, F. C.

CORP: Oak Ridge National Lab., Tenn. AVAIL:NTIS SAP: HC  
A02/MF A01

Presented at the ISA Modeling and Simulation Conf.,  
Pittsburgh, 27 Apr. 1979

MAJS: /\*MATHEMATICAL MODELS/\*OCEAN THERMAL ENERGY CONVERSION  
/\*THERMODYNAMIC EFFICIENCY

MINS: / CONDENSERS (LIQUIFIERS)/ EVAPORATORS/ HEAT TRANSFER/  
OFFSHORE PLATFORMS/ STEAM TURBINES

ABA: DOE

ABS: The thermodynamic process of the open cycle is  
presented and the recent power system studies on the  
subject are summarized. Based on the range of  
operating parameters that have been established in the  
recent system design studies, an optimal thermal  
performance model is developed. The modeling results  
for the case studied indicate that low flashdown  
temperature and higher water velocity in smooth  
condenser tubes maximize the net power per unit  
condenser heat transfer surface area.

79A45843# ISSUE 20 PAGE 3782 CATEGORY 44 CNT#:  
EG-77-C-01-4042 79/00/00 8 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Thermoelectric OTEC

AUTH: A/JAYADEV, T. S.; B/BENSON, D. K.; C/BOHN, M. S.  
PAA: C/(Solar Energy Research Institute, Golden,  
Colo.)

In: Ocean thermal energy for the 80's: Ocean Thermal  
Energy Conversion Conference, 6th, Washington, D.C.,  
June 19-22, 1979, Preprints, Volume 1. (A79-45776  
20-44) Laurel, Md., Johns Hopkins University, 1979, p.  
8D-2/1 to 8D-2/8.

MAJS: /\*OCEAN THERMAL ENERGY CONVERSION/\*THERMOELECTRIC  
POWER GENERATION

MINS: / AMMONIA/ CLOSED CYCLES/ COSTS/ ENERGY POLICY/ ENERGY  
TECHNOLOGY/ HEAT EXCHANGERS/ THERMOELECTRIC GENERATORS

ABA: (Author)

ABS: A novel thermoelectric OTEC concept is proposed and  
compared with the ammonia closed-cycle designs. The  
thermoelectric OTEC is a much simpler system which  
uses no working fluid and therefore requires no  
pressure vessel, working fluid pumps nor  
turbogenerator. These components are replaced by power  
modules which are simply compact heat exchangers  
integrated with thermoelectric generators. The  
thermoelectric OTEC offers several potential  
advantages including: simpler and more easily  
mass-produced components; higher reliability system  
performance through the use of a high level of  
redundancy and long-lived, solid-state thermoelectric  
generators; greater safety for crew and environment by  
elimination of the pressurized working fluid; and the  
possibility of lower system costs. These comparisons  
are discussed and plans for future work are presented  
in the paper.

79A45822# ISSUE 20 PAGE 3812 CATEGORY 48  
79/00/00 9 PAGES UNCLASSIFIED DOCUMENT

UTTL: Ocean thermal and current velocity data requirements  
for design of an OTEC plant - An update

AUTH: A/MOLINARI, R. L. PAA: 4/(NOAA, Physical  
Oceanography Laboratory, Miami, Fla.)

In: Ocean thermal energy for the 80's: Ocean Thermal  
Energy Conversion Conference, 6th, Washington, D.C.,  
June 19-22, 1979, Preprints, Volume 1. (A79-45776  
20-44) Laurel, Md., Johns Hopkins University, 1979, p.  
6A-2/1 to 6A-2/9.

MAJS: /\*DATA ACQUISITION/\*ELECTRIC POWER PLANTS/\*OCEAN  
CURRENTS/\*OCEAN THERMAL ENERGY CONVERSION/\*OFFSHORE  
PLATFORMS/\*WATER TEMPERATURE

MINS: / CLEAN ENERGY/ ENERGY TECHNOLOGY/ FLOW VELOCITY/  
RESOLUTION/ THERMISTORS

BON15572# ISSUE 6 PAGE 760 CATEGORY 44 RPT#:  
ANL/OTEC-BCM-005 CNT# W-31-109-ENG-38 79/05/00  
43 PAGES UNCLASSIFIED DOCUMENT

UTTL: Review of water intake screening options for coastal  
water users with recommendations for Ocean Thermal  
Energy Conversion (OTEC) plants

AUTH: A/THOMAS, D. L.

CORP: Ichthyological Associates, Inc., Arseccon, N.J.  
AVAIL NTIS SAP: HC A03/MF A01

MAJS: /\*COASTAL WATER/\*FILTRATION/\*INTAKE SYSTEMS/\*OCEAN  
THERMAL ENERGY CONVERSION/\*SEA WATER/\*WIRE CLOTH

MINS: / HEAT EXCHANGERS/ OPERATIONS RESEARCH/ PIPES (TUBES)/  
STRUCTURAL ENGINEERING/ SUBMERGED BODIES/ WATER FLOW

ABA: DOE

ABS: Static screens (particularly the profile wire screen  
and the carousel screen) have the potential advantage  
for OTEC for operating in a completely submerged state  
and of being cheaper to operate and maintain than  
traveling screens. However, there is no operational  
history with these static screens for large intake  
systems. The most promising traveling screen options  
for OTEC are the dual flow screens. They offer more  
screening surface and less head loss than through flow  
screens of similar size. They also have been operated  
in seawater for large intake systems. More detailed  
designs of potential OTEC plants, particularly screen  
wells, conduit and surge tank construction and head  
losses need to be determined before the best  
alternative intake screen can be selected.

NB0-11800# Ocean Data Systems, Inc., Monterey, Calif.

OTEC THERMAL RESOURCE REPORT FOR WESTERN  
COAST MEXICO

W A Wolff May 1979 44 p refs

(Contract ET-78-C-01-2898)

(HCP/T2898) Avail NTIS HC A03/MF A01

The site chosen for study off the western coast of Mexico  
between 20 deg 23 deg North latitude, 105 deg 110 deg  
West longitude has a temperature difference resource which is  
more than adequate for potential OTEC use. The annual mean  
delta T of 1000 meters is 20.9 C. An annual mean delta T of  
20.0 C is available at 800 meters. The monthly mean delta T  
for the coldest month of the year is 17.2 C, at 800 meters  
while there is some variation in the monthly mean temperature  
difference, even the coldest month is adequate. The mixed layer  
depth is very shallow throughout the entire year. Storms are a  
problem for this area between May and November. Low sea  
and swell predominate throughout the year. The surface currents  
are generally weak to moderate with some variation in direction  
during the year. The continental shelf is fairly wide for most of  
the region making the distance to shore from depths of  
1000 meters somewhat large. There is one bay from which  
deep water can be reached within 5 kilometers. DOE



BON12564# ISSUE 3 PAGE 354 CATEGORY 44 RPT#:  
SERI/TP-35-254 CONF-700631-6 CNT# EG-77-C-01-4042  
79/06/00 33 PAGES UNCLASSIFIED DOCUMENT

UTTL: Thermoelectric ocean thermal energy conversion

AUTH: A/JAYADEV, T. S.; B/ELNISON, D. K.; C/BOHN, M. S.

CORP: Midwest Research Inst., Golden, Colo. AVAIL: NTIS

SAP: HC A03/MF A01

Presented at the Sixth Intern. OTEC Conf., Washington,  
D.C. 19-22 Jun. 1979

MAJS: /\*ENERGY TECHNOLOGY/\*HEAT EXCHANGERS/\*OCEAN THERMAL  
ENERGY CONVERSION/\*THERMOELECTRIC POWER GENERATION

MINS: / COST ANALYSIS/ RELIABILITY/ SAFETY/ SYSTEMS ANALYSIS  
/ THERMOELECTRIC GENERATORS

ABA: DOE

ABS: A novel thermoelectric ocean thermal energy conversion  
(OTEC) concept was proposed and compared with the  
ammonia closed-cycle designs. The thermoelectric OTEC  
was found to offer several potential advantages  
including: simpler and more easily mass produced  
components; higher reliability system performance  
through the use of a high level of redundancy and  
long-lived, solid state thermoelectric generators;  
greater safety for crew and environment by elimination  
of the pressurized safety for crew and environment by  
elimination of the pressurized working fluid; and the  
possibility of lower system costs.

A literature review of the saturation state of sea-  
water with respect to Calcium Carbonate and its possible  
significance for scale formation on OTEC Heat Exchanger  
By: J.W. Morse, J. De Kanel and H.L. Craig, Jr.

Ocean Engng, Vol. 6, No. 3, 1979, P. 297-315

Abstract—An investigation has been made of available data on the saturation state of seawater with respect to calcium carbonate and its possible significance for scale formation on Ocean Thermal Energy Conversion (OTEC) heat exchangers. Pertinent oceanographic data is lacking at or near potential OTEC sites for the calculation of the degree of saturation of seawater with respect to calcium carbonate. Consequently, only "extrapolated" saturation values can be used. These indicate that near surface seawater is probably supersaturated, with respect to the calcium carbonate phases calcite and aragonite, at all potential OTEC sites. The deep seawater that would be brought to the surface at the potential Atlantic Ocean sites is also likely to be supersaturated with respect to calcium carbonate. The deep seawater at the potential Pacific Ocean sites may be slightly undersaturated.

The fact that OTEC heat exchangers will be operating in seawater, which is supersaturated with respect to calcium carbonate, means that if nucleation of calcite or aragonite occurs on the heat exchanger surfaces, significant growth rates of calcium carbonate scale may be expected. The potential for calcium carbonate nucleation is highest at cathodic metal surface locations, which are produced as the result of aluminum corrosion in seawater. Consequently, corrosion and scale formation may be closely related. What the possible effects of biofouling may be on this process are not known.

79N31812# ISSUE 22 PAGE 2986 CATEGORY 44 RPT#:  
ANL/OTEC-IM-1 CNT# W-31-109-ENG-36 79/01/00 43  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Comparative study of working fluids for OTEC power plants

AUTH: A/GANIC, E. N.; B/WU, J.

CORP: Illinois Univ. at Chicago Circle, Chicago. CSS: 1  
Dept. of Energy Engineering.) AVAIL: NTIS SAP: HC  
A03/MF A01

MAJS: /\*ELECTRIC POWER PLANTS/\*HEAT EXCHANGERS/\*OCEAN  
THERMAL ENERGY CONVERSION/\*WORKING FLUIDS

MINS: / AMMONIA/ COMPUTERIZED SIMULATION/ FREON/ PROPANE

ABA: DOE

ABS: The effect of three different working fluids (ammonia,  
propane, and freon) on the size of ocean thermal  
energy conversion (OTEC) heat exchangers was analyzed.  
Seven different combinations of shell-and-tube heat  
exchangers were considered. For each combination, a  
simple computer model of the OTEC power system was  
used to compare the three fluids. The comparison was  
made on the basis of A/W sub net, where A is the total  
heat transfer area (evaporator plus condenser) and W  
sub net is the net power output of the plant. Overall,  
ammonia is shown to be the best fluid (i.e., it yields  
the lowest value of A/W sub net), although in some  
cases only by a small margin. The thermophysical  
property that gives ammonia its general superiority is  
the relatively high thermal conductivity. The report  
also discusses heat exchanger design problems  
associated with liquid entrainment and boiling liquid  
superheat.

A79-34037

Analysis of various OTEC missions. R. Cohen  
(U.S. Department of Energy, Washington, D.C.) and E. J. Tschupp  
(General Electrical Co., Washington, D.C.). In: Alternative energy  
sources; Proceedings of the Miami International Conference, Miami  
Beach, Fla., December 5-7, 1977. Volume 4. (A79-34036 13-44)  
Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1483-1504.

The market potential for OTEC has been identified as being  
electricity, and energy-intensive products (such as ammonia and  
aluminum). Market penetration scenarios are derived for electrical  
utilities and energy-intensive industries in Southern and Southeastern  
United States, Puerto Rico/Virgin Islands and Hawaii. In addition,  
the potential of the production of hydrogen as an 'electrical bridge'  
to provide peak power at locations remote from OTEC sites is  
considered. A technological experience curve is derived for OTEC  
and applied to an OTEC systems model, to examine the potential  
market penetration scenarios. The institutional and incentive ramifi-  
cations of OTEC market penetration are evaluated along with other  
requirements for OTEC development. The likely benefits of OTEC as  
a domestic energy source are estimated. Possible Federal incentives  
for the stimulation of OTEC commercialization are examined.

(Author)

79A45862# ISSUE 20 PAGE 3796 CATEGORY 45  
79/00/00 7 PAGES UNCLASSIFIED DOCUMENT

UTTL: Environmental monitoring and assessment program at potential OTEC sites

AUTH: A/WILDE, P. PAA: A/(California, University, Berkeley, Calif.)  
In: Ocean thermal energy for the 80's; Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979. Preprints, Volume 2. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 6A-4/1 to 6A-4/7.

MAJS: /\*ENVIRONMENT EFFECTS/\*ENVIRONMENTAL MONITORING/\*OCEAN THERMAL ENERGY CONVERSION/\*WATER POLLUTION

MINS: / ATLANTIC OCEAN/ ECOLOGY/ GULF OF MEXICO/ HAWAII/ OFFSHORE PLATFORMS/ PUERTO RICO/ SOUTH AMERICA

ABA: M.E.P.

ABS: The problem of ensuring the ecologically sound operation of OTEC plants is considered. Attention is given to the need for analysis of the effects of an OTEC plant on the environment, and the influence of the environment on OTEC operations. Four major classes of environmental concerns are covered (1) redistribution of ocean properties (ocean water mixing, impingement/entrainment, climatic/thermal), (2) chemical pollution (biocides, working fluid leaks, corrosion), (3) structural effects (artificial reef, nesting/migration), (4) socio-legal-economic (worker safety, enviro-maritime law, secondary economic impacts). In addition, a program for monitoring at proposed OTEC sites in Hawaii, Puerto Rico, the Gulf of Mexico, and the South Atlantic is described. Model studies and legal compliance activities are also noted

A79-47796 Thermal properties of the Florida Current as related to ocean thermal energy conversion (OTEC). P. A. Mangarella and W. E. Heronemus (Woodward Clyde Consultants, San Francisco, Calif.). *Solar Energy*, vol. 22, no. 6, 1979, p. 527-533. 20 refs. NSF Grant No. GI-34979.

The thermal properties of the Florida Current are presented and analyzed for the available ocean thermal energy. For a cold water intake depth equal to or greater than 600 m, potential sites for ocean thermal energy conversion (OTEC) power plants appear to exist in the Straits of Florida and, to a lesser extent, off the coasts of Georgia and South Carolina. The maximum thermal differences occur on the continental shelf because of the geostrophic motion of the Gulf Stream. An estimate of the total available ocean thermal energy from the Florida Current, delivered in the form of electricity, is  $3.5 \times 10$  to the 12th kWh/yr. For a cold water suction depth of 600 m or more, seasonal variability in the ocean thermal resource is approx. 4 or - 35 per cent of average annual output. (Author)

79A45791# ISSUE 20 PAGE 3777 CATEGORY 44  
79/00/00 10 PAGES UNCLASSIFIED DOCUMENT

UTTL: Preliminary designs of 10 Mwe and 50 Mwe power modules --- for OTEC

AUTH: A/MILLER, R. T.; B/GEPTZ, J. J.; C/CUNNINGHIS, S. PAA: B/(Westinghouse Electric Corp., Steam Turbine-Generator Technical Operations Div., Pittsburgh, Pa.); C/(Gibbs and Hill, Inc., New York, N.Y.)  
In: Ocean thermal energy for the 80's; Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979. Preprints, Volume 1. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 4A-1/1 to 4A-1/10. Research supported by the U.S. Department of Energy.

MAJS: /\*ELECTRIC POWER SUPPLIES/\*MODULES/\*OCEAN THERMAL ENERGY CONVERSION/\*OFFSHORE ENERGY SOURCES/\*SYSTEMS ENGINEERING

MINS: / BLOCK DIAGRAMS/ CLEAN ENERGY/ CONDENSERS/ COST ESTIMATES/ ENERGY TECHNOLOGY/ HEAT EXCHANGERS

ABA: C.F.W.

ABS: The results of preliminary design studies of a closed cycle 10 Mwe modular experiment power system and the related commercial size 50 Mwe power system module are presented. The system design including valve arrangement, evaporator tube bundles and hotwell storage as well as the liquid ammonia, which consists of a mix of condensate from the condenser and recirculated liquid from the evaporator storage, is examined. The heat exchangers and rotating equipment used are scaled logically from 10 Mwe modular experiment size to 50 Mwe modules suitable for commercial plants in the 400 Mwe range. Conclusions show that power system modules for an OTEC power plant can be designed and constructed using proven technology and at a cost that appears competitive with alternative energy plants.

THERMAL ENERGY CONVERSION: TAPPING THE SEA DEPTHS  
Jeffrey H. Rumbaugh, Thomas F. Garrity, Robert Cohen, and Robert L. Sullivan.

IEEE Spectrum, vol 16, no 8, August 1979, p. 42-48.

Floating energy plants could convert heat stored at different ocean levels to electric power.



79A45808# ISSUE 20 PAGE 3836 CATEGORY 84  
79/00/00 10 PAGES UNCLASSIFIED DOCUMENT

UTTL: Legal and institutional aspects --- of OTEC commercialization

AUTH: A/NANDA, V. P. PAA: A/(Denver, University, Denver, Colo.)

In: Ocean thermal energy for the 80's: Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 1. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 40-2/1 to 40-2/10.

MAJS: /\*LAW (JURISPRUDENCE)/MARINE ENVIRONMENTS/\*OCEAN THERMAL ENERGY CONVERSION/\*RESOURCES MANAGEMENT

MINS: / CLEAN ENERGY/ CONTINENTAL SHELVES/ ENERGY POLICY/ ENVIRONMENT PROTECTION/ INTERNATIONAL LAW

ABA: V.P.

ABS: The paper deals with those legal and institutional aspects of the jurisdictional, regulatory, and environmental issues that will ostensibly have a significant bearing on the commercialization of OTEC. They are discussed in the context of both the current and the evolving law, with emphasis on the relationship between the coastal States and the Federal government, and the ongoing negotiations of the Third United Nations Conference on the Law of the Sea. The current state of the law is examined, and the existing ambiguities, gaps, and uncertainties are identified. The need for the development of an imaginative and effective legal and institutional framework is demonstrated, and specific recommendations are made.

A79-51759 An open cycle approach to ocean thermal energy conversion. P. D. Rutland and B. Coffay (Westinghouse Electric Corp., Steam Turbine-Generator Technical Operations Div., Lester, Pa.). In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 195-202. 7 refs. Contract No. EG-77-C-05-1473.

A design for an open cycle 100 MW electric net ocean thermal energy conversion plant is described. In this system flashed seawater is used as the working fluid without resorting to an intermediate working fluid as is used in the closed cycle power system options. The design makes use of an ocean platform as integral part of the power system. A large diameter, low speed turbine with lightweight blades is used. The large quantities of noncondensibles require a special approach to the design of condenser and venting systems. The use of either direct contact or surface condensers is possible with a potential of fresh water production with the use of surface condensers. Attention is paid to hull stability to allow the use of barometric principles for fluid handling. The design, economic, and institutional issues relevant to commercialization are also discussed.

(Author)

79A45857# ISSUE 20 PAGE 3795 CATEGORY 45  
79/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Environmental impact assessment for OTEC-1

AUTH: A/SINAY-FRIEDMAN, L. PAA: A/(TRW Defense and Space Systems Group, Redondo Beach, Calif.)

In: Ocean thermal energy for the 80's: Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 2. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 5C-2/1 to 5C-2/6.

MAJS: /\*BIOLOGICAL EFFECTS/\*ELECTRIC POWER PLANTS/\*ENVIRONMENT EFFECTS/\*HEAT EXCHANGERS/\*OCEAN THERMAL ENERGY CONVERSION

MINS: / AIR POLLUTION/ ENERGY TECHNOLOGY/ ENVIRONMENT PROTECTION/ ENVIRONMENTAL MONITORING/ PLUMES/ WATER INTAKES

ABA: A.T.

ABS: Environmental impact assessment of 1 MWe set of heat exchangers aboard the OTEC-1 early ocean test platform is presented. The key environmental issues assessed were organism entrainment and impingement, ocean water mixing, platform attraction, chlorine releases, ammonia leakage, oil spills, atmospheric pollution, endangered species, and socioeconomic. The overall findings are that nearfield biological effects of OTEC-1 will be localized within a few hundred meters of the vessel, and their impact will be negligible in view of the broad distribution of pelagic organisms. Farfield effects on nearshore populations, whose habitats may be more restricted, will be insignificant.

A80-20886 A thermodynamic assessment of OTEC open-cycle power systems. F. C. Chen (Oak Ridge National Laboratory, Oak Ridge, Tenn.). In: Modeling and simulation, Volume 10 - Proceedings of the Tenth Annual Pittsburgh Conference, Pittsburgh, Pa., April 25-27, 1979, Part 3. (A80-20881 06-44) Pittsburgh, Pa., Instrument Society of America, 1979, p. 921-926. 7 refs. Contract No. W-7405-eng-26.

The thermodynamics of open-cycle OTEC power systems are reviewed, and the expected performance of open-cycle plants is assessed. A temperature-entropy diagram of the open-cycle process is presented and related to the various components of the system. Results of recent major open-cycle plant studies for floating platform systems in the submerged, semisubmerged and spar buoy configurations are summarized. An optimal thermal performance model is developed for a generalized open-cycle turbine on the basis of the range of operating parameters established in the system design studies and applied to a typical system. It is found that, for the given system, the performance (net power output per heat transfer area) tends to maximize at a small flashdown temperature and high water velocity: smooth condenser tubes.

A.L.W.

79A45777# ISSUE 20 PAGE 3776 CATEGORY 44  
79/00/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Eurocean OTEC project

AUTH: A/LACHMANN, B. A. P. L. PAA: A/(Association  
Européenne Océanique, Monaco)

In: Ocean thermal energy for the 80's: Ocean Thermal  
Energy Conversion Conference, 6th, Washington, D.C.,  
June 19-22, 1979, Preprints, Volume 1. (A79-45776  
20-44) Laurel, Md., Johns Hopkins University, 1979, p.  
2A-1/1 to 2A-1/5.

MAJS: /ELECTRIC POWER PLANTS/ INTERNATIONAL COOPERATION/  
OCEAN THERMAL ENERGY CONVERSION/ PILOT PLANTS

MINS: / COST ESTIMATES/ DESALINIZATION/ ENERGY SOURCES/  
ENERGY TECHNOLOGY/ EUROPE/ INDUSTRIAL ENERGY/ SYSTEMS  
ENGINEERING

ABA: A.T.

ABS: The Eurocean ocean thermal energy conversion (OTEC)  
work and the proposal for a 10 Mwe closed cycle pilot  
plant are reviewed. OTEC activities including cost  
estimates for 100 MW commercial size floating plants  
and combination with agriculture using the artificial  
upwelling or combination with biomass production for  
food, fertilizer, or fuel are discussed. The 10 Mwe  
pilot plant will be built to test the OTEC system with  
full size modules, to verify the cost estimates for  
the commercial plant, and to examine possible use of  
less costly materials. Costs of OTEC electricity are  
compared with the costs of oil fueled power  
electricity. A feasibility study combining  
aquaculture/OTEC/desalination project is described.

**A80-17135 Ocean thermal energy conversion (OTEC) -  
Social and environmental issues.** A. Lavi (Carnegie-Mellon University,  
Pittsburgh, Pa.) and G. H. Lavi (ERDI, Inc., Pittsburgh, Pa.). (*United  
Nations University, East-West Center, International Institute for  
Applied Systems Analysis, and University of Hawaii, Conference on  
Non-Fossil Fuel and Non-Nuclear Fuel Energy Strategies, Honolulu,  
Hawaii, Jan. 9-12, 1979.*) *Energy (UK)*, vol. 4, Oct. 1979, p.  
833-840. 13 refs.

Economic, social and environmental issues in the commercializa-  
tion of OTEC are addressed, assuming technical feasibility and cost  
competitiveness, at least in certain areas. The market potential of  
OTEC on U.S. islands and in near-shore regions of the mainland is  
assessed and the economics of commercialization are considered. It is  
concluded that the private ownership of OTEC plants and facilities is  
not likely without government financial incentives, and the nature of  
possible incentives is outlined. Environmental problems of OTEC are  
discussed, noting ocean water mixing, chemical leakages, CO2 release  
from deep cold water and the presence of large numbers of plants  
and electric cables, and institutional questions of baseload OTEC  
plant licensing, regulation, world market impact and labor require-  
ments are considered. It is concluded that OTEC represents a  
beneficial long-term option. A.L.W.

79A45838# ISSUE 20 PAGE 3781 CATEGORY 44  
79/00/00 3 PAGES UNCLASSIFIED DOCUMENT

UTTL: Steady-state and dynamic performance of an OTEC plant  
AUTH: A/KAYTON, M. PAA: A/(TRW Defense and Space Systems  
Group, Redondo Beach, Calif.)

In: Ocean thermal energy for the 80's: Ocean Thermal  
Energy Conversion Conference, 6th, Washington, D.C.,  
June 19-22, 1979, Preprints, Volume 1. (A79-45776  
20-44) Laurel, Md., Johns Hopkins University, 1979, p.  
8B-2/1 to 8B-2/3.

MAJS: /COMPUTERIZED SIMULATION/ DYNAMIC RESPONSE/ ENERGY  
CONVERSION EFFICIENCY/ MATHEMATICAL MODELS/ OCEAN  
THERMAL ENERGY CONVERSION

MINS: / ENERGY TECHNOLOGY/ FLUID FLOW/ HEAT EXCHANGERS/  
POWER EFFICIENCY/ PUMPS/ SHIPS/ STEADY STATE/  
TEMPERATURE DEPENDENCE

ABA: V.P.

ABS: The paper deals with a mathematical model that was  
used for performance analysis of the PSD-1 and PSD-2  
plants and for designing the control systems. The  
steady-state model includes simulations of such major  
system elements as heat exchangers (heat transfer and  
flow losses), moisture separator, turbine, pumps,  
pipes, fittings, and valves. The model is organized  
into subroutines that can be individually modified. A  
relaxation algorithm determines the steady-state flows  
and temperatures, given the dimensions and other  
variables. The steady-state model achieves 1% accuracy  
in power, 0.3 psi accuracy in pressure, and 0.1 F  
accuracy in temperature.

**TK Intersociety Energy Conversion Engineering  
2896 Conference, 14th, Boston, 1979.  
.155 Proceedings of the 14th Intersociety  
1979 Energy Conversion Engineering Conference,  
Boston, Massachusetts, August 5-10, 1979.  
-- Washington, D. C. : American Chemical  
Society, c1979.**

**799033 OTEC Technology Overview Development  
Program, S. Gronich ..... 164**

**799026 OTEC Ammonia Turbine Design Study, C.H.  
Kostors and S.P. Vincent ..... 148**

**799037 Preliminary Design of a Cruising OTEC Mod-  
ular Experiment, J.F. George and D. Richards ..... 183**

79A45832# ISSUE 20 PAGE 3781 CATEGORY 44

79/00/00 7 PAGES UNCLASSIFIED DOCUMENT

UTTL: Recent developments in the foam OTEC system

AUTH: A/ZENER, C.; B/MOLINI, A.; C/FORT, T.; JR.;

D/FETKOVICH, J.; E/GREENSTEIN, M. PAA:

E/(Carnegie-Mellon University, Pittsburgh, Pa.)

In: Ocean thermal energy for the 80's: Ocean Thermal

Energy Conversion Conference, 6th, Washington, D.C.,

June 19-22, 1979. Preprints, Volume 1. (A79-45776

20-44) Laurel, Md., Johns Hopkins University, 1979, p.

7C-2/1 to 7C-2/7.

MAJS: /FOAMING/OCEAN THERMAL ENERGY CONVERSION/TECHNOLOGY  
ASSESSMENT

MINS: /ENERGY TECHNOLOGY/ FLOW CHARACTERISTICS/ SURFACTANTS  
/ WATER FLOW

ABA: A.T.

ABS: Analysis of the foam formation in the OTEC open cycle is presented. In this cycle warm water lifts itself several hundred feet, with a behavior which appeared to depend in a capricious manner on the temperature of the incoming water, the pressure of the spray condenser, and the foam mass flow rate. Foam making and foam breaking, the governing equations for the rise of a foam column, superheated incoming warm water, super pressurized incoming warm water, laminar vs turbulent flow, and surfactant concentration and slippage are discussed. An equation which governs the steady state rise of a foam column was derived by analysis and experiment, and it predicts the effects of controllable parameters, including the diameter and height of the column, on the foam behavior. It is shown that foam flows laminarily rather than turbulently, and has a well defined drag function. The drag function decreases as the inverse square of the column diameter.

N79-31812# Illinois Univ. at Chicago Circle, Chicago. Dept.  
of Energy Engineering.

#### COMPARATIVE STUDY OF WORKING FLUIDS FOR OTEC POWER PLANTS

E. N. Ganic and J. Wu. Jan. 1979 48 p refs

(Contract W-31-109-eng-38)

(ANL/OTEC-TM-1) Avail. NTIS HC A03/MF A01

The effect of three different working fluids (ammonia, propane, and freon) on the size of ocean thermal energy conversion (OTEC) heat exchangers was analyzed. Seven different combinations of shell-and-tube heat exchangers were considered. For each combination, a simple computer model of the OTEC power system was used to compare the three fluids. The comparison was made on the basis of A/W sub net, where A is the total heat transfer area (evaporator plus condenser) and W sub net is the net power output of the plant. Overall, ammonia is shown to be the best fluid (i.e., it yields the lowest value of A/W sub net), although in some cases only by a small margin. The

79A45854# ISSUE 20 PAGE 3836 CATEGORY 84

79/00/00 9 PAGES UNCLASSIFIED DOCUMENT

UTTL: Legal aspects of siting OTEC plants offshore the United States, on the high seas, and offshore other countries

AUTH: A/HYHART, J. D. PAA: A/(MIT, Cambridge, Mass.)

In: Ocean thermal energy for the 80's: Ocean Thermal

Energy Conversion Conference, 6th, Washington, D.C.,

June 19-22, 1979. Preprints, Volume 2. (A79-45776

20-44) Laurel, Md., Johns Hopkins University, 1979, p.

4D-1/1 to 4D-1/9.

MAJS: /ELECTRIC POWER PLANTS/ENERGY SOURCES/INTERNATIONAL  
LAW/OCEAN SURFACE/OCEAN THERMAL ENERGY CONVERSION/  
OFFSHORE ENERGY SOURCES

MINS: /COASTAL WATER/ ENERGY TECHNOLOGY/ ENVIRONMENT  
PROTECTION/ REGULATIONS

ABA: A.T.

ABS: The legal issues of siting OTEC plants offshore in U.S. and foreign countries and on the high seas are presented. The legal questions for each specific site are presented in terms of international legal and political framework, international arrangements, regulatory law, criminal law, private and residual law, and financing. In comparing the OTEC sites in the three areas, it is found that the sea law will result in coastal state dominance of sites within 200 miles offshore, and the international arrangements will seek benefits for the U.S. and foreign countries, and more attractive investment by private sources, and will be defensive in nature in protecting U.S. interests. Recommendations regarding OTEC and the law of the sea conference include legislation regulating the deployment and operation of OTEC devices within 200 miles off its coast, and changes in criminal and private law for OTEC development and commercialization.

A80-28259

The MINI-OTEC test. R. L. Waid (Lockheed Missiles and Space Co., Inc., Sunnyvale, Calif.). In: OCEANS '79; Proceedings of the Fifth Annual Combined Conference, San Diego, Calif., September 17-19, 1979. (A80-28251 10-99) New York, Institute of Electrical and Electronics Engineers, Inc., 1979, p. 548-552. Research supported by the Lockheed Missiles and Space Co.

MINI-OTEC is the first at-sea, closed-loop OTEC system using warm surface water and cold deep water to generate electrical power. The thermal resource and current environment at the test site, Keahole Point, Hawaii, are discussed. The OTEC power system and components are described as are the components of the ocean system. At-sea operating experience of an OTEC plant, including biofouling effects and countermeasure effectiveness, are the primary objectives of the project. The characteristics and loads of vortex-induced flow around the cold water pipe are described. (Author)



79A45846# ISSUE 20 PAGE 3782 CATEGORY 44  
79/00/00 7 PAGES UNCLASSIFIED DOCUMENT

UTTL: Electric utility system planning studies for OTEC power integration

AUTH: A/PEREZ BRACETTI, F. PAA: A/(Puerto Rico Water Resources Authority, San Juan, P.R.)  
In: Ocean thermal energy for the 80's; Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 2. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 38-2/1 to 38-2/7.

MAJS: /\*COST EFFECTIVENESS/\*ELECTRIC POWER PLANTS/\*OCEAN THERMAL ENERGY CONVERSION/\*SYSTEMS ENGINEERING

MINS: / ENERGY TECHNOLOGY/ ENVIRONMENT PROTECTION/ POLLUTION CONTROL/ PUERTO RICO/ RELIABILITY ANALYSIS

ABA: A.T

ABS: The plan of generation expansion study assuming availability of commercial OTEC plants together with the coal, oil, and nuclear utilities is discussed. Generation system, electrical system, licensing, and environmental problems are considered, with generation expansion based on a system planning method using reliability criteria complemented with analyses of reserve requirements. Alternative generation expansion schemes, reliability evaluation, energy production costs, and OTEC break-even requirements are included in the plan, with determination of costs for various voltages, capacities, and maximum reliability cable configurations considered in the electrical portion of the plan. The licensing of a stationary sea floating facility and the role of regulatory agencies is discussed. The design of the environmental study is focused on the OTEC platform attraction for the pelagic organisms, and the nature and extent of this effect is an important factor in OTEC platform siting bearing potential effect on project feasibility.

A80-20424 OTEC - Solar energy from the sea. R. H. Douglass, Jr. (TRW Defense and Space Systems Group, Systems Engineering and Integration Div., Redondo Beach, Calif.). *Quest*, vol. 3, Autumn 1979, p. 3-29.

The principles and history of ocean thermal energy conversion (OTEC) are discussed, along with U.S. and foreign OTEC programs, where all proposed OTEC plants use the Rankine cycle. Particular attention is given to OTEC components such as the mechanically durable 0.030 inch thick tube walls of the heat exchanger. The working fluid of modern closed cycle systems is ammonia, and mechanical cleaning and chlorination are used against biofouling. Heat exchanger types, including shell-and-tube, plate-fin, and trombone are considered, as well as the hull of the plant, its platform, sea water pumps, and differently designed cold water pipes. Moreover, computer models designed to study performance sensitivity to various operating parameters are discussed. J.P.B.

79A45841# ISSUE 20 PAGE 3781 CATEGORY 44 CNT#:  
W-7405 79/00/00 9 PAGES UNCLASSIFIED DOCUMENT

UTTL: The mist-transport cycle - Progress in economic and experimental studies --- OTEC power plant

AUTH: A/CHARWAT, A. F.; B/HAMMOND, R. P.; C/RIDGWAY, S. L. PAA: A/(California, University, Los Angeles, Calif.); C/(R & D Associates, Marina del Rey, Calif.)  
In: Ocean thermal energy for the 80's; Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 1. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 80-3/1 to 80-3/9.

MAJS: /\*COST ESTIMATES/\*ELECTRIC POWER PLANTS/\*MIST/\*OCEAN THERMAL ENERGY CONVERSION/\*OFFSHORE PLATFORMS

MINS: / DESIGN ANALYSIS/ ECONOMIC ANALYSIS/ ENERGY BUDGETS/ ENERGY TECHNOLOGY/ PROTOTYPES/ THERMODYNAMIC CYCLES

ABA: (Author)

ABS: A preliminary design and cost analysis of an OTEC power plant utilizing the mist transport cycle has been conducted. Arbitrary choices for the expected lift tube losses were made; other losses estimated from conservative engineering practice. The plant cost is lift efficiency insensitive, and is of the order of \$1000/kW. An experimental facility has been constructed by UCLA for the purpose of studying the essential fluid dynamics of the mist generation and mist transport process - a 3 ft diameter 24 ft tall vertical flow two-phase tunnel with supplies of vacuum, warm and cold water. An orifice plate mist generator is at the bottom, and a vapor condenser is at the top. The equipment shakedown phase is nearing completion, and data collection is beginning.

N80-12684# Midwest Research Inst., Golden, Colo.  
THERMOELECTRIC OCEAN THERMAL ENERGY CONVERSION

T. S. Jayadev, D. K. Benson, and M. S. Bohn Jun. 1979 33 p  
refs Presented at the Sixth Intern. OTEC Conf., Washington, D.C., 19-22 Jun. 1979

(Contract EG-77-C-01-4042)

(SERI/TP-35-254; CONF-790631-6)

Avail: NTIS

HC A03/MF A01

A novel thermoelectric ocean thermal energy conversion (OTEC) concept was proposed and compared with the ammonia closed cycle designs. The thermoelectric OTEC was found to offer several potential advantages including: simpler and more easily mass produced components; higher reliability system performance through the use of a high level of redundancy and long-lived, solid state thermoelectric generators; greater safety for crew and environment by elimination of the pressurized safety for crew and environment by elimination of the pressurized working fluid; and the possibility of lower system costs. DOE

79A45844# ISSUE 20 PAGE 3782 CATEGORY 44

79/00/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: Hybrid OTEC cycle avoids indirect heat exchangers

AUTH: A/JAHNIG, C. E.

In: Ocean thermal energy for the 80's: Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 1. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 80-3/1 to 80-3/4.

MAJS: /\*OCEAN THERMAL ENERGY CONVERSION/\* THERMODYNAMIC CYCLES/\*WORKING FLUIDS

MINS: / AIR/ COST ESTIMATES/ DESIGN ANALYSIS/ ENERGY TECHNOLOGY/ ENVIRONMENT EFFECTS/ PISTONS

ABA: M.E.P.

ABS: A hybrid OTEC cycle which uses air as a working fluid is presented. Indirect heat exchangers are avoided and the air is alternately warmed and cooled by direct contact with water to produce useful work from the expansion and contraction. Methods are described to decrease the buoyancy and size of equipment, such as by increasing the compression beyond that caused by the temperature change alone. In addition no water pumps are used since pressure changes produce the desired flow, making the system well suited to combinations with industrial manufacturing and aquaculture. Finally, based on a conceptual design the hybrid system can produce electric power of 2.9 cents/kWh compared to 3.9 cents/kWh by conventional technology burning coal.

**N80-19638#** Naval Coastal Systems Center, Panama City, Fla.  
**DATA ANALYSIS FOR OCEAN THERMAL ENERGY CONVERSION (OTEC)**

Susah M. Tuovila Nov. 1979 36 p.

(AD-AC77908; NCSC-TM-271-79)

Avail: NTIS

HC A03/MF A01 CSCL 08/10

Ocean Thermal Energy Conversion (OTEC) is the concept for a system which will extract energy from the ocean by taking advantage of the sizable temperature difference between surface and bottom water in a tropical ocean. A fundamental part of an OTEC system is a large section of heat exchangers through which the energy transfer is made. It is crucial to keep the surface of these heat exchangers clean because fouling by organisms in sea water can cause deterioration of the heat transfer effectiveness. The Naval Coastal Systems Center (NCSC) investigated cleaning techniques that would effectively prevent fouling in metal tubes over a long period of time. The physical structure and cleaning systems of the OTEC assembly at Panama City, Florida have been described in several papers and will be dealt with only briefly here. This report will describe the computer driven control and data analysis system used in conjunction with the mechanical system. This will include explanations of the physical computer setup and its interaction with hardware components of the system, the software methods of sampling and data management, and data analysis techniques. A brief discussion of the underlying theory of heat transfer is also included. GRA

79A45784# ISSUE 20 PAGE 3776 CATEGORY 44

79/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: OTEC goes to sea /A review of Mini-OTEC/

AUTH: A/TRIMBLE, L. C.; B/POTASH, R. L. PAA: B/(Lockheed Missiles and Space Co., Inc., Sunnyvale, Calif.)  
In: Ocean thermal energy for the 80's: Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 1. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 3A-2/1 to 3A-2/6. Research supported by the Lockheed Missiles and Space Co. and Dillingham Corp.

MAJS: /\*ELECTRIC POWER PLANTS/\*HEAT EXCHANGERS/\*OCEAN SURFACE/\*OCEAN THERMAL ENERGY CONVERSION

MINS: / COLD WATER/ ENERGY TECHNOLOGY/ MOORING/ OFFSHORE PLATFORMS/ PIPE FLOW/ WATER DEPTH/ WATER FLOW

ABA: A.T.

ABS: An overview of the Mini-OTEC project, including a description of the power plant, control system, instrumentation, cold water pipe (CWP) mooring system, and platform is presented. The Mini-OTEC is the first floating at-sea closed loop system using surface and deep seawater to generate 50 kW output, and it is installed on a moored barge incorporating CWP in the single anchor leg. Design data for heat exchangers, the turbine generator, fluid systems, control system, and instrumentation are presented. An engineering description of the moor, characteristics of the barge, specifications for the polyethylene CWP, and the crossover hose are provided. A static analysis was made to select a mooring leg configuration, component lengths, and anchor weight, and a dynamic analysis of the system response in a storm was performed to select line diameters, pipe and hose wall thickness, and bury depth. A time-domain dynamic program was developed to simulate the seaway-induced motions and loads of the coupled mooring components.

**A80-23220**

Sea thermal power - Competitive electricity and chemicals from the sea. J. H. Anderson (Sea Solar Power, Inc., York, Pa.) and D. F. Mayer. In: Advances in energy systems and technology. Volume 2. (A80-23218 08-44) New York, Academic Press, Inc., 1979, p. 49-100. 17 refs.

Sea thermal power (STP) is reviewed with attention given to operating cycles, environmental impact, energy transmission, the development of a 100-MW sea solar power plant, and the economic perspective. A detailed development program is proposed and consideration is given to program cost and the outlook for the future. B.J.



**UTTL:** Dynamic and off-design analysis of OTEC closed cycle power systems

**AUTH:** A/WESTERBERG, A. W.; B/YAO, S.; C/JENNINGS, S. J.; D/COLEMAN, W. H. PAA: B/(Carnegie-Mellon University, Pittsburgh, Pa.); D/(Westinghouse Electric Corp., Pittsburgh, Pa.)

In: Ocean thermal energy for the 80's; Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 1. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. BB-1/1 to BB-1/12.

**MAJS:** /\*CLOSED CYCLES/\*DESIGN ANALYSIS/\*DYNAMIC RESPONSE/\*ELECTRIC POWER PLANTS/\*ENERGY CONVERSION EFFICIENCY/\*OCEAN THERMAL ENERGY CONVERSION

**MINS:** / AUXILIARY POWER SOURCES/ AVAILABILITY/ COMPUTERIZED SIMULATION/ ECONOMIC FACTORS/ FLOW VELOCITY/ FLUID FLOW/ HEAT EXCHANGERS/ PUMPS/ RANKINE CYCLE/ SYSTEMS STABILITY

**ABA:** V.P.

**ABS:** In the present study, power system analytical simulation programs were used to formulate and analyze an advanced OTEC Rankine cycle. Least cost optimization algorithms, involving pattern search techniques, were used to show that anhydrous ammonia is the most suitable working fluid. A unique power plant configuration was developed and shown to provide maximum power cycle efficiency. Dynamic and off-design conditions were simulated on the OTEC power plant, and the requirements for heat exchanger hotwell capacities, liquid ammonia pump characteristics, connecting pipe sizes, valve specifications, storage capacities, and condenser venting loops were identified.

**N80 15571#** Midwest Research Inst., Golden, Colo.

**ALTERNATE CYCLES APPLIED TO OCEAN THERMAL ENERGY CONVERSION**

B. Shelpuk and A. Lewandowski Feb. 1979 14 p. refs. Presented at the 11th Ann. Offshore Technol. Conf., Houston, Tex., 30 Apr. - 3 May 1979

(Contract EG-77-C-01-4042)

(SERI/TP-34-180; CONF-790444-3) Avail: NTIS HC A02/MF A01

Four open cycle OTEC concepts are described. These are (1) single, vertical-axis turbine; (2) multiple, horizontal axis turbine; (3) foam lift/hydraulic turbine; and (4) mist lift/hydraulic turbine. A preliminary assessment of achievable performance is made in addition to a description of the subsystem performance objectives which would support the achievement of the full potential inherent in these concepts. The results and conclusions include a description of the research objectives, achievement of which make open cycle OTEC a viable alternative as a national energy source.

DOE

**UTTL:** Potential for ocean thermal energy conversion electric power generation in the Southeast region

**AUTH:** A/SUTHERLAND, P. L.; B/AREY, F. G., JR.; C/GUILD, D. H. PAA: A/(Florida Power and Light Co., Miami, Fla.); C/(Stone and Webster Engineering Corp., Boston, Mass.)

In: Ocean thermal energy for the 80's; Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 2. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 5A-1/1 to 5A-1/6.

**MAJS:** /\*COST EFFECTIVENESS/\*ELECTRIC POWER PLANTS/\*OCEAN THERMAL ENERGY CONVERSION/\*THERMOELECTRIC POWER GENERATION

**MINS:** / COMPUTER PROGRAMS/ DOMESTIC ENERGY/ ENERGY SOURCES/ ENERGY TECHNOLOGY/ LIFE CYCLE COSTS

**ABA:** A.T.

**ABS:** Evaluation of the operating characteristics and investment costs of an OTEC electric power plant in the Southeast U.S. is presented. Conceptual design of an OTEC plant is discussed with the capital cost estimate, and conventional coal fuel plant costs. A computer analysis is made of the life cycle costs of electric power generation with conventional generating plants, and an OTEC plant substituted for a coal plant of a capacity that provides equal system reliability. A present worth of revenue requirements cost analysis is then made of the revised system expansion plan that includes the OTEC plant. The comparative difference between the present worth life cycle costs of the two expansion plans determine the break-even capital investment that can be made in an OTEC plant. It is concluded that OTEC holds the greatest promise in comparison to other renewable energy sources available in the Southeast for central station power generation.

**A79-31415**

An ocean thermal difference power plant in the Canadian Arctic. R. K. Swartman (Western Ontario, University, London, Canada) and R. Green. In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 12 p. 17 refs.

A variation on the scheme of using the temperature differences of the ocean waters is to use the Arctic atmosphere as the heat sink and ocean waters as the source. The proposed system uses a closed Rankine cycle operating between the temperatures of the Arctic Ocean and the colder Arctic atmosphere. The working fluid is evaporated in a vapor generator by the transfer of heat from seawater and is condensed after passing through a turbine, rejecting heat to the atmosphere. Two essential components of this proposal are a seawater-working fluid heat exchanger for the vapor generator and an air-working fluid heat exchanger for the condenser.

G.R.

79A45779# ISSUE 20 PAGE 3776 CATEGORY 44  
79/00/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: An overview of the Japanese OTEC development

AUTH: A/HOMMA, T.I. B/KANOGAWA, H. PAA: A/(Ministry of International Trade and Industry, Electrotechnical Laboratory, Tokyo, Japan); B/(Toshiba Corp., Research and Development Center, Kawasaki, Japan)  
In: Ocean thermal energy for the 80's: Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 1. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 2A-3/1 to 2A-3/5.

MAJS: /\*DOMESTIC ENERGY/\*ECONOMIC ANALYSIS/\*ELECTRIC POWER PLANTS/\*FEASIBILITY ANALYSIS/\*OCEAN THERMAL ENERGY CONVERSION

MINS: / ENERGY SOURCES/ ENERGY TECHNOLOGY/ JAPAN/ PILOT PLANTS/ SYSTEMS ENGINEERING

ABA: A.T.

ABS: Design of 100 MW OTEC power plants, experimental studies of the power cycle, and application and assessment of OTEC systems in Japan are reviewed. A dynamic analysis was made of the platform and platform structure for the 100 MW commercial plant to optimize the plant configuration and its anchoring system. Optimum conceptual design of 100 Mw plants on board of ship type and submerged disk type platforms was carried out and the major specifications and costs are given. Heat exchanger development with several types of tubes and tube plates is discussed, noting that titanium tubes are the best to resist corrosion, erosion, and biofouling. Studies of uranium exploration by OTEC and the possibility of marine biological productivity enhancement are described. The long time engineering test in the ocean environment will use a 1 MWe power system on board a barge with ammonia as a working fluid, and will be equipped with test facilities to evaluate the environmental effects.

PRELIMINARY SELECTION OF ANCHOR SYSTEMS FOR OCEAN THERMAL ENERGY CONVERSION. J.M. Atturio, P.J. Valent, and R.J. Taylor.

Ocean Engineering. v. 6, 1979, pp. 139-167, no. 1/2.

EXTRACTING ENERGY FROM WARM SEAWATER.

Gregg Marland.

Endeavour, vol 2, no 4, 1978, p. 165-169.

79A45778# ISSUE 20 PAGE 3776 CATEGORY 44  
79/00/00 7 PAGES UNCLASSIFIED DOCUMENT

UTTL: French OTEC program

AUTH: A/MARCHAND, P. PAA: A/(Centre National pour l'Exploitation des Oceans, Paris, France)  
In: Ocean thermal energy for the 80's: Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 1. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 2A-2/1 to 2A-2/7.

MAJS: /\*DOMESTIC ENERGY/\*OCEAN THERMAL ENERGY CONVERSION/\* OFFSHORE ENERGY SOURCES/\*PILOT PLANTS

MINS: / ELECTRIC POWER PLANTS/ ENERGY TECHNOLOGY/ FRANCE/ OFFSHORE PLATFORMS/ PIPE FLOW/ WATER FLOW

ABA: A.T.

ABS: The OTEC program which plans to build a pilot ocean thermal energy conversion (OTEC) plant in the 1 to 10 MWe range is reviewed. Past French experience in OTEC is discussed, and the feasibility study, testing of major components, and designing of the 1 to 10 MWe pilot plant are described. The shore based power plant concept is considered, noting the problem of laying cold water pipe. Open cycle OTEC schemes have several advantages over closed-cycle schemes using ammonia, and they produce desalinated water at nominal cost, although sea-water requires deaeration. The shore-based concept and the floating concept are being studied, and the use of offshore technology for the design of floating units is considered. It is concluded that the first small and middle-sized OTEC power plants will be located in equatorial islands.

SINGLE ANCHOR HOLDING CAPACITIES FOR OCEAN THERMAL ENERGY CONVERSION (OTEC) IN TYPICAL DEEP SEA SEDIMENTS. P.J. Valent, R.J. Taylor, J.M. Atturio, and R.M. Beard.

Ocean Engineering. v. 6, 1979, pp. 169-245, no. 1/2.

54395 (ANL/OTEC-BCM-002) Proceedings of the Ocean Thermal Energy Conversion (OTEC) Biofouling, Corrosion, and Materials Workshop, January 8-10, 1979, Rosslyn, Virginia. (Argonne National Lab., IL (USA)). 1979. Contract W-31-109-ENG-38. 349p. Dep. NTIS, PC A15/MF A01.

The 23 papers presented are entered in the data base separately. Round table sessions on measurement of R/sub f/ and analysis of heat transfer data, biology of fouling, corrosion and the application of materials, and fouling and countermeasures are included. (WHK)

79A45783# ISSUE 20 PAGE 3776 CATEGORY 44  
79/00/00 10 PAGES UNCLASSIFIED DOCUMENT

UTTL: OTEC ocean engineering progress report

AUTH: A/SHERWOOD, W. G.; B/WALSH, J. P. PAA: A/(U.S. Department of Energy, Washington, D.C.); B/(Value Engineering Co., Alexandria, Va.)  
In: Ocean thermal energy for the 80's: Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 1. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 3A-1/1 to 3A-1/10.

ABA: A.T.

ABS: The OTEC ocean engineering program to extract solar energy stored in the ocean surface water and to deliver it to the U.S. at a marketable price is reviewed. The thermodynamic system to extract the stored energy, the supporting equipment, and means of delivering it are considered as objectives of the OTEC program. The objective of the ocean engineering program is the design and construction of the resource delivery system. Platform subsystems, land-based plants, plant ship, and a spar platform for the 40 MWe plant are discussed. Design of the cold water pipe is considered, including bottom-mounted pipe, tensioned pipe, and pipe joints. It is concluded that a technical base of platform designs, cold water pipe designs, and moor designs has been provided for designing, building, and operating a 40 MWe OTEC plant.

79A45846# ISSUE 20 PAGE 3782 CATEGORY 44 CNT#:  
ET-78-C-03-1785 79/00/00 15 PAGES UNCLASSIFIED DOCUMENT

UTTL: An overview of the OTEC-1 design --- including mooring, anchoring, site selection, installation, manufacturing, etc

AUTH: A/SVENSEN, N. A. PAA: A/(Global Marine Development, Inc., Newport Beach, Calif.)  
In: Ocean thermal energy for the 80's: Ocean Thermal Energy Conversion Conference, 6th, Washington, D.C., June 19-22, 1979, Preprints, Volume 2. (A79-45776 20-44) Laurel, Md., Johns Hopkins University, 1979, p. 3A-3/1 to 3A-3/15.

MAJS: /\*ANCHORS (FASTENERS)/\*OCEAN THERMAL ENERGY CONVERSION  
/\*SHIPS/\*SYSTEMS ENGINEERING/\*TECHNOLOGY ASSESSMENT/\*  
WATER CIRCULATION  
MINS: / ASSEMBLING/ ENERGY TECHNOLOGY/ INSTALLING/  
MANUFACTURING/ MOORING/ PIPE FLOW

ABA: A.T.

ABS: An overview of the OTEC-1 system design including the vessel, the cold water pipe and deep water discharge, the power loop, the mooring system, and the anchoring site selection are presented. Systems integration is described in terms of interface design and installation requirements, manufacturing and assembly constraints, and materials considerations. The site survey is included to show the basis for the novel anchor design. The T-2 tanker Chepachet used for the OTEC-1 experiment has the ammonia power cycle located in a compartment provided by converting three ships centerline cargo tanks.

Energy, v.4, no.5

Oct.  
1979

RENEWABLE ENERGY PROSPECTS. (Special issue).  
(Proceedings of a Conference on Non-Fossil Fuel  
and Non-Nuclear Fuel Energy Strategies.  
Held in Honolulu, Hawaii, Jan.9-12,1979.  
Sponsored by the United Nations University at  
Tokyo, Japan). Wilfrid Bach, et al. eds.

Lavi, A. and Lavi, G. H.: Ocean thermal energy conversion (OTEC): social and environmental issues

833

**Abstract** OTEC converts the solar energy, collected and stored in tropical waters, into electricity. The electricity may be either cabled to shore or used *in situ* for the manufacture of energy-intensive products. Two countries, U.S.A. and Japan, are seriously pursuing OTEC. The development programs in both countries are similar. Presently, the emphasis is on the closed Rankine cycle with ammonia as the working fluid. The power plants are to be housed on floating platforms. If the electricity is to be cabled to shore, the platforms will be moored to the ocean floor. If the plants are to produce chemical products, they will graze from one location to another on the open sea to capture the largest available thermal resource.

Technical feasibility of OTEC appears certain. In the near term, OTEC can be economical for U.S. islands, which depend on imported oil for power generation. OTEC can enter the U.S. mainland market in the Southeast if projected capital cost for large plants is realized and high voltage, underwater d.c. transmission is developed beyond current state of the art. The islands market amounts to 8 GW and the U.S. market is estimated to be much larger. Penetration of the island market can begin in the early 1990s and of the mainland market after the year 2000.

A potential impediment to OTEC's accelerated deployment is capital. Although there are numerous important environmental and institutional questions, they are secondary to the economic and cost issues.

This paper addresses the economic, social and environmental issues pertinent to the commercialization of OTEC. The *a priori* assumptions are that technical problems can be solved and that in certain locations, OTEC can be competitive with conventional base-load power systems.



OCEAN THERMAL ENERGY - STATUS AND PROSPECTS.  
W. H. Avery  
Marine Technology Society Journal, Vol. 12,  
No. 2, April/May 1978, p. 9-16.

The purpose of my talk is to give you a brief overview of the program called ocean thermal energy conversion or OTEC, which is now being recognized as a potential major contributor to U.S. and world energy supplies. The term OTEC describes a method for generating power by using the warm water at the surface of the tropical oceans, in combination with the cold water available at a depth of half a mile, to operate a heat engine.

TJ  
153  
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1978  
Energy Technology Conference, 5th, Washington, D.C., 1978.  
Energy technology V : challenges to technology : proceedings of the fifth Energy Technology Conference, February 27-March 1, 1978, Washington, D.C. / edited by Richard F. Hill. -- Washington : Government Institutes, 1978.

OTEC PROGRAM STATUS AND PLANS p. 554  
Sigmund Gronich, Chief, Ocean Systems Branch, Department of Energy

MARKET PENETRATION FOR OTEC p. 576  
Robert Cohen, Ocean Systems Branch, Department of Energy

N79-29626# Argonne National Lab., Ill. Energy and Environmental Systems

#### OTEC POWER SYSTEMS

Jeffrey S. Horowitz 1978 29 p refs Presented at ASME Energy Technol. Conf. and Exhibition, Houston, Tex., 5-9 Nov. 1978

(Contract W-31-109-eng-38)

(CONF-781112-12) Avail: NTIS HC A03/MF A01

At present a major part of the OTEC Program is the power system development (PSD). Currently the PSD activity is divided into three parts: PSD 1, PSD 2, and support activities. PSD 1

is the design of a 50 MWe power system using shell and tube heat exchangers in which three contractors are involved. PSD 2 is a parallel effort which pursues the same goals with the use of nonshell-and-tube heat exchangers. The support activities center about the development of heat exchangers. Each of these areas are described, and the relationships between PSD and the remainder of the OTEC Program are discussed. DOE

GULF STREAM OTEC RESOURCE POTENTIAL  
W. R. McCluney and L. D. Sivak  
J. Energy, Vol. 2, no. 2, March-April 1978, p120-122

TEMPERATURE differences in the tropical and subtropical oceans, between the warm surface waters and colder waters at depths of several hundred feet, offer a potential resource for useful energy extraction. By circulating an appropriate fluid (ammonia for example) through a conventional type of heat engine cycle, the fluid can be vaporized by the warmer surface waters, made to pass through and drive a turbine electric generator, and condensed for reuse in the cycle by the cold deep water drawn into the plant. The utilization of this temperature difference in the oceans for electrical energy production has been termed Ocean Thermal Energy Conversion (OTEC).

N80-12800# Gibbs and Cox, Inc., Washington, D/C  
OCEAN THERMAL ENERGY CONVERSION (OTEC) PLATFORM CONFIGURATION AND INTEGRATION. EXECUTIVE SUMMARY Final Report

R. J. Scott Jul. 1978 205 p refs

(Contract EG-77-C-01-4064)

(DOE/ET-4064-1) Avail: NTIS HC A09/MF A01

Studies leading to the development of conceptual designs for two 400 MW Offshore Thermal Energy Conversion (OTEC) commercial plants are summarized. A detailed overview of the study is presented. The successful deployment of a commercial OTEC plant in the near term is dependent upon the optimization of the platform configuration and power plant output level. The optimization procedure is based on both technical and economic factors and is used to evaluate a relatively large number of alternatives, i.e., six hullforms, five plant outputs ranging from 50 to 500 megawatts (MW), and three deployment sites. The hullforms under consideration include the ship (barge), cylinder (disc), spar, submersible, semi-submersible, and sphere; while the deployment sites are Hawaii, New Orleans, and Key West. The second part of the summary describes the development of the two platforms selected by DOE to be carried through the conceptual design level: a 400 MW ship and semi-submersible.

DOE

N80-13713# Rosenblatt (M.) and Son, Inc., New York  
OTEC PLATFORM CONFIGURATION AND INTEGRATION. APPENDIXES TO VOLUME 2 Final Report

7 Jul 1978 159 p

(Contract EG-76-C-01-4065)

(DOE/ET-4065/1-Vol-2 App) Avail: NTIS HC A08/MF A01

Detailed information and conceptual design drawings for the spar and sphere platforms for an OTEC commercial plant are presented. A work breakdown structure and a detailed estimate of the spar platform weight are included. DOE

**N79-28767#** Gibbs and Cox, Inc., Washington, D. C.  
**OCEAN THERMAL ENERGY CONVERSION (OTEC) PLATFORM CONFIGURATION AND INTEGRATION. VOLUME 1: SYSTEMS REQUIREMENTS AND EVALUATION** Final Report

Jun. 1978 415 p refs

(Contract EG-77-C-01-4064)

(DOE/ET/4064-1-Vol-1) Avail: NTIS HC A18/MF A01

Studies leading to the development of two 400 MW offshore thermal energy conversion commercial plants are presented. This volume includes a summary of three tasks: task 2A-systems evaluation and requirements; task 2B-evaluation plan; task 3-technology review; and task 4-systems integration evaluation. Task 2A includes the definition of top level requirements and an assessment of factors critical to the selection of hull configuration and size, quantification of payload requirements and characteristics, and sensitivity of system characteristics to site selection. Task 2B includes development of a methodology for systematically evaluating the candidate hullforms, based on interrelationships and priorities developed during task 2A. Task 3 includes the assessment of current technology and identification of deficiencies in relation to OTEC requirements and the development of plans to correct such deficiencies. Task 4 involves the formal evaluation of the six candidate hullforms in relation to site and plant capacity to quantify cost/size/capability relationships, leading to selection of an optimum commercial plant. DOE

**N79-28750#** Lockheed Missiles and Space Co., Sunnyvale, Calif.  
**OTEC PLATFORM CONFIGURATION AND INTEGRATION STUDY. VOLUME 3: PROJECT PLAN** Final Report

Apr. 1978 15 p ref

(Contract EC-77-C-01-4053)

(DOE/ET/4063-1-Vol-3: LMSC-D623756-Vol-3) Avail: NTIS HC A02/MF A01

The characteristics which were desired in the demonstration plant are discussed and the demonstration activities for that plant are commented on. The cost, scale, and state of development of the technology the plant employs are covered. DOE

**32950** (PB-283104) Renewable ocean energy sources. Part I. Ocean thermal energy conversion. (Office of Technology Assessment (U.S. Congress), Washington, DC). May 1978. 50p. NTIS PC A03/MF A01.

This report details the current status of OTEC technology with particular attention to areas in which significant problems exist. It discusses the economic considerations which are pertinent to an OTEC system and outlines economic problems facing some of the products most often suggested for OTEC production. The final sections of the report deal with the present and possible future Government role in funding OTEC research.

**N80-10647#** Oak Ridge National Lab., Tenn. Metals and Ceramics Div.

**STATE OF THE ART SURVEY OF JOINABILITY OF MATERIALS FOR OTEC HEAT EXCHANGERS**

R. J. Beaver Dec 1978 85 p refs

(Contract W-7405 eng 26)

(ORNL/TM-6284) Avail: NTIS HC A05/MF A01

Literature and industrial sources were surveyed to assess, on the basis of apparent economics and reliability, the joinability of both shell-and-tube and compact ocean thermal energy conversion (OTEC) heat exchangers. A no-leak requirement is mandatory to prevent mixing seawater and the ammonia working fluid. The operating temperature range considered is 7 to 28 C (45 to 82 F). Materials evaluated were aluminum, titanium, copper-nickel, AL-6X austenitic stainless steel, singly and in combination with steel and concrete. Many types of welding and brazing processes, roller expansion, magnaforming, O-ring sealing, and adhesive bonding were considered. The automatic gas tungsten-arc welding process and explosion welding processes are the only two joining processes that now appear to offer the high reliability required of no-leak shell-and-tube heat exchangers. Of the two processes, the gas tungsten-arc welding process appears to be the more economically attractive. DOE

**N80-13712#** Rosenblatt (M.) and Son, Inc., New York.  
**OTEC PLATFORM CONFIGURATION AND INTEGRATION. VOLUME 2: TECHNICAL CONCEPT** Final Report

7 Jul. 1978 307 p refs

(Contract EG-77-C-01-4065)

(DOE/ET-4065/1-Vol-2) Avail: NTIS HC A14/MF A01

The configuration, integration, and evaluation studies performed for commercial OTEC applications are presented. The results of conceptual designs for the platforms, the facilities and equipment required for construction, deployment, operation of the OTEC platforms, and cost estimates and time schedules are discussed. DOE

**N80-14555#** Miami Univ., Coral Gables, Fla. Clean Energy Research Inst.

**FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE. VOLUME 1, SECTIONS 1-3**

A. Lavi, ed. (DOE, Washington, D.C.) and T. N. Veziroglu, ed. Sep. 1978 695 p refs Conf. held at Miami Beach, Fla., 20-22 Feb. 1978

(Grant EG-77-G-05-5550)

(CONF-780236-P1) Avail: NTIS HC A99/MF A01

The advancements made in the past year in the ocean engineering aspects of the ocean thermal energy conversion (OTEC) program are described. Commercial plant studies are presented on the power system, coal water pipe system, and the seawater system. Topics discussed include the power system development, the heat exchangers system, alternate power cycles, and biofouling and corrosion effects. A.W.H.

**N80-14553#** Miami Univ., Coral Gables, Fla. Clean Energy Research Inst.

**FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE. VOLUME 2, SECTIONS 4-5**

A. Lavi, ed. and T. N. Veziroglu, ed. Sep. 1978 592 p refs Conf. held at Miami Beach, Fla., 20-22 Feb. 1978

(Grant EG-77-G-05-5550)

(CONF-780236-P2) Avail: NTIS HC A25/MF A01

Contents: ocean thermal energy conversion (OTEC) platform design optimization; considerations in selection of OTEC platform size and configuration; OTEC-1 early ocean test project; preliminary engineering design of an OTEC pilot plant; operational sea state and design wave criteria; OTEC platform station keeping analysis; OTEC cold water pipe design loads; dynamic loads induced by severe storms in elastic cold water pipes attached to OTEC ships by fixed and hinged connections; conceptual design of an OTEC power system using modular heat exchangers; power system module configuration using aluminum heat exchangers. R.E.S.

**N79-28748#** Lockheed Missiles and Space Co., Sunnyvale, Calif.  
**OTEC PLATFORM CONFIGURATION AND INTEGRATION STUDY: EXECUTIVE SUMMARY** Final Report

Apr. 1978 41 p refs

(Contract EC-77-C-01-4063)

(DOE/ET/4063-1: LMSC-D623756)

Avail: NTIS HC A03/MF A01

Conceptual designs of ship-type and spar-type platforms for Ocean Thermal Energy Conversion (OTEC) commercial plants are presented. Comparative evaluation of six candidate platform types is made. Design guidelines for sea water, cold water pipe and position control systems are developed. Costs are presented for plants with outputs of 400 MWe (net) for operational sites of New Orleans, Hawaii, and Brazil. DOE



78N28619\*# ISSUE 19 PAGE 2557 CATEGORY 44

78/00/00 19 PAGES UNCLASSIFIED DOCUMENT

UTTL: Impact of novel energy sources: OTEC, wind, geothermal, biomass

AUTH: A/ROBERTS, A. S., JR.

CORP: Old Dominion Univ., Norfolk, Va. AVAIL NTIS SAP: HC A07/MF A01

In NASA, Langley Res. Center Emerging Energy Alternatives for Southeastern States p 39-57 (SEE N78-28615 19-44)

MAJS: /\*BIOMASS ENERGY PRODUCTION/\*ENERGY POLICY/\*GEOTHERMAL RESOURCES/\*OCEAN THERMAL ENERGY CONVERSION/\*WINDPOWER UTILIZATION

MINS: / COMMERCIAL ENERGY/ DEVELOPMENT/ ENERGY CONVERSION EFFICIENCY

ABA: Author

ABS: Alternate energy conversion methods such as ocean thermal energy conversion (OTEC), wind power, geothermal wells and biomass conversion are being explored, and re-examined in some cases, for commercial viability. At a time when United States fossil fuel and uranium resources are found to be insufficient to supply national needs into the twenty-first century, it is essential to broaden the base of feasible energy conversion technologies. The motivations for development of these four alternative energy forms are established. Primary technical aspects of OTEC, wind, geothermal and biomass energy conversion systems are described along with a discussion of relative advantages and disadvantages of the concepts. Finally, the sentiment is voiced that each of the four systems should be developed to the prototype stage and employed in the region of the country and in the sector of economy which is complimentary to the form of system output.

**N80-13656/** Rosenblatt (M.) and Son, Inc., New York.

**OTEC PLATFORM CONFIGURATION AND INTEGRATION.**

**VOLUME 1: SYSTEMS ENGINEERING AND INTEGRATION**

**Final Report**

7 Jul 1978 228 p refs

(Contract EG-77-C-01-4055)

(TID-29418) Avail NTIS HC A11/MF A01

An evaluation methodology was developed for the purpose of analyzing the ocean system requirements against the site criteria and in arriving at the conclusions as far as hull, seawater system, positioning system, and other ocean systems characteristics. Feasibility studies and cold water pipe/hull stress analyses indicated that the best platform hull shape would be one that would have a submerged main body and the cold water pipe would be attached to it in a flexible joint type configuration, possibly with flexible joints along the length as well. The best positioning system would be a static mooring system, possibly 3-leg, using hollow cylindrical links for lines. DOE

79N29626# ISSUE 20 PAGE 2694 CATEGORY 44 PPT#:  
CONF-781112-12 CNT# W-31-109-ENG-38 78/00/00 29  
PAGES UNCLASSIFIED DOCUMENT

UTTL: OTEC power systems

AUTH: A/HOROWITZ, J. S.

CORP: Argonne National Lab., Ill. CSS: (Energy and Environmental Systems.) AVAIL NTIS SAP: HC A03/MF A01

Presented at ASME Energy Technol. Conf. and Exhibition, Houston, Tex., 5-9 Nov. 1978

MAJS: /\*PROJECT PLANNING/\*SYSTEMS ENGINEERING/\*TUBE HEAT EXCHANGERS

MINS: / ENERGY TRANSFER/ HEAT EXCHANGERS/ HEAT TRANSFER/ HEATING EQUIPMENT/ PROGRAMS

ABA: DOE

ABS: At present a major part of the OTEC Program is the power system development (PSD). Currently the PSD activity is divided into three parts: PSD 1, PSD 2, and support activities. PSD 1 is the design of a 50 MWe power system using shell and tube heat exchangers in which three contractors are involved. PSD 2 is a parallel effort which pursues the same goals with the use of nonshell-and-tube heat exchangers. The support activities center about the development of heat exchangers. Each of these areas are described, and the relationships between PSD and the remainder of the OTEC Program are discussed.

79N15435# ISSUE 6 PAGE 746 CATEGORY 44 PPT#:

NTIS/PS-78/1224/1 NTIS/PS-77/1057 NTIS/PS-76/0902

78/11/00 128 PAGES UNCLASSIFIED DOCUMENT

Supersedes NTIS/PS-77/1157; NTIS/PS-76/0902

UTTL: Solar sea power plants. Citations from the engineering index data base TLSP: Progress Report, 1970 - Oct. 1978

AUTH: A/HUNDEMANN, A. S.

CORP: National Technical Information Service, Springfield, Va. AVAIL NTIS SAP: HC \$28.00/MF \$28.00

MAJS: /\*BIBLIOGRAPHIES/\*ELECTRIC GENERATORS/\*OCEAN THERMAL ENERGY CONVERSION/\*SOLAR SEA POWER PLANTS

MINS: / CORROSION PREVENTION/ ECONOMIC ANALYSIS/ FEASIBILITY ANALYSIS/ HEAT EXCHANGERS

ABA: GRA

ABS: The present status and future prospects of using the ocean thermal gradient for production of electric power are discussed in these citations from worldwide research. Engineering, economic, and feasibility studies are covered, including studies dealing with systems and component design. This updated bibliography contains 124 abstracts, 25 of which are new entries to the previous edition.

79N29654# ISSUE 20 PAGE 2697 CATEGORY 44 RPT#:  
CONF-781109-17 CNT#: W-31-109-ENG-38 78/11/00 12  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Assessment and control of OTEC physical environmental  
impacts --- conferences

AUTH: A/DITMARS, J. D.

CORP: Argonne National Lab., Ill. AVAIL NTIS SAP: HC  
A02/MF A01

Presented at Environmental Control Symp., Washington,  
D. C., 28 Nov. 1978

MAJS: /\*CONFERENCES/\*ENVIRONMENTAL SURVEYS/\*INDUSTRIAL  
WASTES/\*OCEANS/\*WATER POLLUTION

MINS: / DATA ACQUISITION/ ECOLOGY/ ELECTRIC POWER PLANTS/  
SCALE MODELS/ STRATIFICATION

ABA: DOE

ABS: Physical model studies at laboratory scales provided  
data on the potential for resource degradation as a  
function of plant design and receiving water  
characteristics as well as the pathways and mixing of  
plant trajectories. Continuing physical model studies  
explore near-plant effluent behavior further for  
variations in upper ocean stratification and currents.  
Predictions of intermediate-field spreading and mixing  
are necessary to estimate impacts in the far wake of a  
plant and bear on spacing between plants. The results  
of near-plant and intermediate-field effluent behavior  
provide the input and boundary conditions for models  
that simulate the large-scale transport of OTEC  
perturbations.

78N29622# ISSUE 20 PAGE 2694 CATEGORY 44 RPT#:  
PB-280728/7 NOAA-TM-ERL-AOML-30 NOAA-78041216  
78/01/00 33 PAGES UNCLASSIFIED DOCUMENT

UTTL: Ocean thermal and current velocity data requirements  
for design of an OTEC demonstration plant

AUTH: A/MOLINARI, R. L.; B/FESTA, J. F.

CORP: National Oceanic and Atmospheric Administration,  
Miami, Fla. AVAIL NTIS SAP: HC A03/MF A01

MAJS: /\*ELECTRIC POWER PLANTS/\*OCEAN CURRENTS/\*OCEAN THERMAL  
ENERGY CONVERSION/\*VELOCITY MEASUREMENT

MINS: / ENVIRONMENT EFFECTS/ OCEANOGRAPHIC PARAMETERS/  
STRUCTURAL DESIGN CRITERIA/ TEMPERATURE MEASUREMENT

ABA: GRA

ABS: The requirements for oceanographic data needed in the  
design of an OTEC demonstration plant and a  
methodology for obtaining ocean thermal and current  
velocity data are presented. In addition, some  
requirements for environmental impact data are given.

78A25057 ISSUE 9 PAGE 1525 CATEGORY 23  
78/02/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Ocean thermal energy conversion material requirements  
for large-scale systems

AUTH: A/MCGOWAN, J. G.; B/HEFONEMUS, W. E. PAA:  
B/(Massachusetts, University, Amherst, Mass.)

Metallurgical Transactions A - Physical Metallurgy and  
Materials Science, vol. 9A, Feb. 1978, p. 207-214.

MAJS: /\*ELECTRIC POWER PLANTS/\*ENERGY TECHNOLOGY/\*OCEAN  
THERMAL ENERGY CONVERSION

MINS: / HEAT EXCHANGERS/ MOORING/ POSITIONING/ SEA WATER/  
TURBINES

ABA: (Author)

ABS: This paper summarizes the general concepts and current  
state of the art for Ocean Thermal Energy Conversion  
(OTEC) Systems, a large-scale solar energy driven  
resource. Specifically, it focuses on the varied  
material needs for such power plants. Each of the  
system's major components (turbine, heat exchanger,  
ocean platform or hull, and ocean water delivery  
system) is discussed with respect to material  
requirements (type and magnitude) needed for the  
various designs. The heat exchangers are considered to  
be the key power plant components and various designs  
and material choices are presented. Also, the impact  
on material resources for large-scale implementation  
of such systems is considered.

78A52597 ISSUE 24 PAGE 4373 CATEGORY 44  
78/10/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: OTEC Electricity from the ocean

AUTH: A/WHITMORE, W. F. PAA: A/(Lockheed Missiles and  
Space Co., Inc., Sunnyvale, Calif.)  
Technology Review, vol. 61, Oct. 1978, p. 58-63.

MAJS: /\*ELECTRIC POWER PLANTS/\*OCEAN THERMAL ENERGY  
CONVERSION/\*OFFSHORE ENERGY SOURCES

MINS: / CLEAN ENERGY/ ECONOMIC FACTORS/ ENERGY TECHNOLOGY/  
FEASIBILITY ANALYSIS

ABA: P.T.H.

ABS: Although thermodynamically inefficient (2.5%), OTEC  
plants become competitive in view of the fact that the  
fuel (sun's energy) is free. Major cost element is the  
massive heat exchangers operating at 40 F temperature  
differences of less than 40 F. A design for a single  
25-Mw modular unit requires about 640 miles of  
two-inch tubing, in either aluminum or titanium.  
Methods of removing slime from the heat exchangers  
without detriment to marine environment are being  
developed. The current estimate for the cost of a  
moored OTEC plant is about \$2000/kw capacity, with  
costs decreasing with improvements in heat exchangers.

79A35059 ISSUE 14 PAGE 2620 CATEGORY 44  
78/00/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Ocean Thermal Energy Conversion /OTEC/ power plant  
instrumentation and measurement  
AUTH: A/LEWIS, L. G. PAA: A/(Argonne National Laboratory,  
Argonne, Ill.)  
In: Seminar on Testing Solar Energy Materials and  
Systems, Gaithersburg, Md., May 22-24, 1976,  
Proceedings. (A79-35008 14-44) Mt. Prospect, Ill.,  
Institute of Environmental Sciences, 1978, p. 134-138.  
MAJS: /\*ENERGY SOURCES/\*OCEAN THERMAL ENERGY CONVERSION/  
POWER PLANTS  
MINS: / CORROSION TESTS/ ENERGY TECHNOLOGY/ FLOW MEASUREMENT  
/ FOULING/ HEAT EXCHANGERS/ HEAT TRANSFER COEFFICIENTS  
/ PPESSURE MEASUREMENTS/ TEMPERATURE MEASUREMENT/  
WATER FLOW  
ABA: S.D.  
ABS: The primary goal of the OTEC program is to promote the  
use of the ocean thermal energy resource. The paper  
describes the measurements required in the power  
cycle, and to determine the accuracies needed to  
properly evaluate the effects of corrosion, fouling  
and cleaning. Instruments are discussed which can  
provide data for evaluating the performance of OTEC-1  
heat exchangers when subjected to corrosion,  
biofouling, and cleaning. The accuracies obtainable  
for the calculated overall heat transfer coefficient  
and for gross power developed are adequate for the  
projected needs of the OTEC-1 program. The data  
obtained on OTEC-1 will be sufficient to predict the  
long-term performance of an OTEC power generating  
plant.

79N28748# ISSUE 19 PAGE 2575 CATEGORY 44 RPT#:  
DOE/ET/4063-1 LMSC D623756 CMT#: EC-77-C-01-4063  
78/04/00 41 PAGES UNCLASSIFIED DOCUMENT

UTTL: OTEC platform configuration and integration study:  
Executive summary TLSP: Final Report  
CORP: Lockheed Missiles and Space Co., Sunnyvale, Calif.  
AVAIL NTIS SAP: HC A02/NE AD1  
MAJS: /\*OCEAN THERMAL ENERGY CONVERSION/\*OFFSHORE PLATFORMS  
MINS: / CONTROL/ COST ANALYSIS/ SEA WATER/ SYSTEMS  
ENGINEERING  
ABA: DOE  
ABS: Conceptual designs of ship-type and spar-type  
platforms for Ocean Thermal Energy Conversion (OTEC)  
commercial plants are presented. Comparative  
evaluation of six candidate platform types is made.  
Design guidelines for sea water, cold water pipe and  
position control systems are developed. Costs are  
presented for plants with outputs of 400 Mwe (net) for  
operational sites of New Orleans, Hawaii, and Brazil.

79A27378 ISSUE 10 PAGE 1835 CATEGORY 44  
78/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Technology considerations in the design of a  
commercial offshore energy conversion /OTEC/ plant  
AUTH: A/ROGALSKI, W. W., JR.; B/SCOTT, R. J.; C/GIANIOTTI,  
J. G. PAA: B/(Gibbs and Cox, Inc., Arlington, Va.);  
C/(Giannotti and Buck Associates, Inc., Riverdale,  
Md.)  
In: Oceans '78: The ocean challenge: Proceedings of  
the Fourth Annual Combined Conference, Washington,  
D.C., September 6-8, 1978. (A79-27378 10-48)  
Washington, D.C., Marine Technology Society; New York,  
Institute of Electrical and Electronics Engineers,  
Inc., 1978, p. 363-368.  
MAJS: /\*ELECTRIC POWER PLANTS/\*OFFSHORE ENERGY SOURCES/\*  
OFFSHORE PLATFORMS/\*SYSTEMS ENGINEERING  
MINS: / CLEAN ENERGY/ DESIGN ANALYSIS/ ENERGY TECHNOLOGY/  
PUMPS/ TECHNOLOGY ASSESSMENT  
ABA: (Author)  
ABS: The design and construction of an OTEC plant slated to  
produce electricity for commercial consumption in the  
near future presents a number of unique problems and  
is forcing the advancement of the state of the art in  
ocean structures in a number of fields. The successful  
deployment of a commercially viable OTEC plant is  
dependent upon identifying these technology areas and  
developing a program to insure that any potential  
program obstacles are adequately addressed.

79N15434# ISSUE 6 PAGE 746 CATEGORY 44 RPT#:  
NTIS/PS-78/1223/3 NTIS/PS-77/1056 NTIS/PS-76/0901  
78/11/00 215 PAGES UNCLASSIFIED DOCUMENT  
Supersedes NTIS/PS-77/1056; NTIS/PS-76/0901

UTTL: Solar sea power plants. Citations from the NTIS data  
base TLSP: Progress Report, 1964 - Oct. 1978  
AUTH: A/HUNDEMANN, A. S.  
CORP: National Technical Information Service, Springfield,  
Va. AVAIL NTIS SAP: HC 570.01/78 \$28.00  
MAJS: /\*BIBLIOGRAPHIES/\*ELECTRIC GENERATORS/\*OCEAN THERMAL  
ENERGY CONVERSION/\*SOLAR SEA POWER PLANTS  
MINS: / CORROSION PREVENTION/ ECONOMIC ANALYSIS/ FEASIBILITY  
ANALYSIS/ HEAT EXCHANGERS  
ABA: GRA  
ABS: Federally-funded research studies dealing with the  
technical and economic feasibility of solar sea power  
plants are discussed. Topic areas cover condenser,  
evaporator, and heat exchanger design; and, fouling  
and corrosion prevention. Site selection, dynamic  
modeling studies, and general studies dealing with  
solar sea power as an energy alternative are included.  
This updated bibliography contains 210 abstracts, 59  
of which are new entries to the previous edition.



79A34037 ISSUE 13 PAGE 2416 CATEGORY 44

78/00/00 22 PAGES UNCLASSIFIED DOCUMENT

UTTL: Analysis of various OTEC missions --- market potential of applications

AUTH: A/COHEN, R.; B/TSCHUPP, E. J. PAA: A/(U.S. Department of Energy, Washington, D.C.); B/(General Electrical Co., Washington, D.C.)

In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4. (A79-34036 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978. p. 1483-1504.

MAJS: /\*ELECTRIC POWER/\*INDUSTRIAL ENERGY/\*MARKET RESEARCH/\* OCEAN THERMAL ENERGY CONVERSION/\*TECHNOLOGY UTILIZATION

MINS: / ALUMINUM/ AMMONIA/ CLEAN ENERGY/ ENERGY TECHNOLOGY/ HYDROGEN PRODUCTION/ UTILITIES

ABA: (Author)

ABS: The market potential for OTEC has been identified as being electricity, and energy-intensive products (such as ammonia and aluminum). Market penetration scenarios are derived for electrical utilities and energy-intensive industries in Southern and Southeastern United States, Puerto Rico/Virgin Islands and Hawaii. In addition, the potential of the production of hydrogen as an 'electrical bridge' to provide peak power at locations remote from OTEC sites is considered. A technological experience curve is derived for OTEC and applied to an OTEC systems model, to examine the potential market penetration scenarios. The institutional and incentive ramifications of OTEC market penetration are evaluated along with other requirements for OTEC development. The likely benefits of OTEC as a domestic energy source are estimated. Possible Federal incentives for the stimulation of OTEC commercialization are examined.

N80-13714# Rosenblatt (M.) and Son, Inc., New York.

OTEC PLATFORM CONFIGURATION AND INTEGRATION.

VOLUME 3: PROJECT PLAN Final Report

7 Jul 1978 64 p refs

(DOE/ET-4065/1-Vol-3) Avail. NTIS HC A04/MF A01

The spar and sphere offshore platforms were used to demonstrate the feasibility of a near full size ocean thermal energy conversion (OTEC) plant and to gather data for use in the construction, design and operation of commercial OTEC plants. A hull size suitable to support a 100 MWe net output plant was chosen. Construction of the hull and installation of all equipment is proposed for three sites: (1) a shoreside construction site, (2) an offshore site in sufficient water depth to complete the hull erection, and (3) installation of the cold water pipe at the demonstration site. DOE

79A34038 ISSUE 13 PAGE 2416 CATEGORY 44

78/00/00 15 PAGES UNCLASSIFIED DOCUMENT

UTTL: An update of OTEC baseline design --- cost estimates and market potential

AUTH: A/CURTO, P. A. PAA: A/(Mitre Corp., METREK Div., McLean, Va.)

In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4. (A79-34036 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978. p. 1505-1519.

MAJS: /\*COST ESTIMATES/\*MARKET RESEARCH/\*OCEAN THERMAL ENERGY CONVERSION/\*OFFSHORE ENERGY SOURCES

MINS: / CLEAN ENERGY/ DESIGN ANALYSIS/ ENERGY TECHNOLOGY/ HEAT EXCHANGERS/ OFFSHORE PLATFORMS/ SITES

ABA: B.J.

ABS: A review of ocean thermal energy conversion (OTEC) systems was conducted for the purpose of estimating OTEC costs and probable market penetration in U.S. energy markets. The Lockheed, TRW, and Applied Physics Laboratory concepts were examined. A generic OTEC grid-connected, floating, spar-buoy, fixed-position system concept was chosen as likely to be the most cost-effective of the configurations for which preliminary designs currently exist. An update of this OTEC generic design is presented along with cost estimates for each of the primary subsystems.

79A15869# ISSUE 4 PAGE 644 CATEGORY 44

78/04/00 23 PAGES UNCLASSIFIED DOCUMENT

UTTL: An introduction to ocean thermal energy conversion /OTEC/ power plants

AUTH: A/PONT, R. J. PAA: A/(Lockheed Missiles and Space Co., Inc., Sunnyvale, Calif.)

Institute of Gas Technology, Energy from the Sun Symposium, Chicago, Ill., Apr. 3-7, 1978. Paper, 23 p.

MAJS: /\*ECONOMIC ANALYSIS/\*ELECTRIC POWER PLANTS/\*ENERGY POLICY/\*OCEAN THERMAL ENERGY CONVERSION

MINS: / COST ESTIMATES/ ENERGY TECHNOLOGY/ GULF OF MEXICO/ PRODUCT DEVELOPMENT/ STRUCTURAL ENGINEERING

ABA: M.L.

ABS: The history and prospects of ocean thermal energy conversion (OTEC) are discussed, and the basic economics of OTEC are examined. An OTEC plant concept is described, some technical and institutional problems affecting OTEC plants are indicated, and possible solutions to the problems are considered. It is suggested that OTEC plants will be cost competitive with conventional plants in the Mexican Gulf region by about 2000.

79A34043 ISSUE 13 PAGE 2494 CATEGORY 83  
78/00/00 26 PAGES UNCLASSIFIED DOCUMENT

UTTL: The commercialization of OTEC - Problems and opportunities  
AUTH: A/LAVI, G. H. PAA: A/(Carnegie-Mellon University, Pittsburgh, Pa.)  
In: Alternative energy sources: Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4. (A79-34036 13-44)  
Washington, D.C., Hemisphere Publishing Corp., 1978. p. 1587-1612.

MAJS: /\*COMMERCIAL ENERGY/\*GOVERNMENT/INDUSTRY RELATIONS/\*  
MARKET RESEARCH/\*OCEAN THERMAL ENERGY CONVERSION  
MINS: / CLEAN ENERGY/ COST ESTIMATES/ ECONOMIC FACTORS/  
ENERGY POLICY/ ENERGY TECHNOLOGY/ FINANCE/ OPERATIONAL  
PROBLEMS

ABA: B.J.

ABS: A growth scenario is examined to determine the steps industry and government must take to achieve OTEC market penetration at the earliest possible date. Consideration is given to capital and resource requirements, and to growth rate of manufacturing capacity and product demand. It is suggested that it is questionable whether the private sector can undertake the commercialization of OTEC without government incentives and a well-established public policy for this new energy technology. It is shown that with the proper incentives OTEC can begin to penetrate the U.S. energy market by the year 2000.

BON13711# ISSUE 4 PAGE 507 CATEGORY 44 RPT#:  
DOE/ET-4065/1 CNT#: EG-76-C-01-4065 78/07/26 97  
PAGES UNCLASSIFIED DOCUMENT

UTTL: OTEC platform configuration and integration, executive summary TLSP: Final Report

CORP: Rosenblatt (M.) and Son, Inc., New York. ACALLNTIS  
SAP: HC A05/MF A01

MAJS: /\*ENERGY POLICY/\*OCEAN THERMAL ENERGY CONVERSION/\*  
SYSTEMS ANALYSIS

MINS: / INDUSTRIAL PLANTS/ MARINE TECHNOLOGY/ OCEANOGRAPHY/  
STRUCTURAL DESIGN CRITERIA

ABA: A.W.H.

ABS: The commercialization of the ocean thermal energy conversion (OTEC) concept is discussed. Various areas of the OTEC plant development are examined. These include the design of a marine vessel to house the OTEC power cycle, the development of an OTEC power cycle, studies of the site environment, and the effects of biofouling and corrosion on any of the OTEC components.

79A26192# ISSUE 9 PAGE 1616 CATEGORY 44  
78/00/00 18 PAGES UNCLASSIFIED DOCUMENT

UTTL: Working fluids and turbines for OTEC power systems  
AUTH: A/ROGARD, D. D. PAA: A/(Westinghouse Electric Corp., Steam Turbine Div., Lester, Pa.)

In: Fluids engineering in advanced energy systems: Proceedings of the Winter Annual Meeting, San Francisco, Calif., December 10-15, 1978. (A79-26175 09-44) New York, American Society of Mechanical Engineers, 1978. p. 229-246.

MAJS: /\*ENERGY CONVERSION EFFICIENCY/\*ENGINE DESIGN/\*OCEAN  
THERMAL ENERGY CONVERSION/\*TURBINE ENGINES/\*WORKING  
FLUIDS

MINS: / CENTRIFUGAL FORCE/ DESIGN ANALYSIS/ ENERGY  
TECHNOLOGY/ OUTLET FLOW/ PERFORMANCE PREDICTION/ SOLAR  
ENERGY CONVERSION/ STRESS CONCENTRATION/ TURBINE  
BLADES

ABA: P.T.H.

ABS: The paper discusses the thermodynamic and mechanical relations which affect the performance and size limitations of designs for the turbine of open-cycle ocean thermal energy conversion. Two key design parameters influencing turbine efficiency are the velocity ratio and the average gauging ratio (ratio of total flow area at throat of blades to total annulus area). It is shown that the optimum velocity ratio varies only slightly with gauging, and that higher values of gauging lead to lower efficiency as a result of higher axial exit velocity. The blade bending stresses are also taken into account in evaluating limiting performance. Parameters of an illustrative turbine design using the largest available disk (17 ft in diameter) are given. The combination of speed, diameter, and blade length are well within the limits of acceptable centrifugal stresses for a variety of blade materials including steel, titanium, aluminum, or fiberglass.

A79-16245 Ocean thermal energy conversion; Proceedings of the Energy Technology Conference and Exhibition, Houston, Tex., November 6-9, 1978. Conference sponsored by the American Society of Mechanical Engineers. Edited by O. M. Griffin (U.S. Navy, Naval Research Laboratory, Washington, D.C.). New York, American Society of Mechanical Engineers (Ocean Engineering Symposia Series, OED Volume 5), 1978. 110 p. Members, \$9.00; nonmembers, \$18. (For individual items see A79-16246 to A79-16251)

An overview of the U.S. OTEC program is presented and consideration is given to OTEC power systems development, and the capital cost optimization of OTEC power modules. Attention is also given to advances in the ocean engineering aspects of OTEC, and power cables to accommodate the motions of an OTEC plant. B.J.



78A35876 ISSUE 14 PAGE 2565 CATEGORY 44  
78/05/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Ocean thermal energy - Status and prospects

AUTH: A/AVERY, W. H. PAA: A/(Johns Hopkins University,  
Laurel, Md.)

(Marine Technology Society and American Institute of  
Mining, Metallurgical and Petroleum Engineers, Special  
Symposium, Rosslyn, Va., Sept. 15, 1977.) Marine  
Technology Society Journal, vol. 12, Apr.-May 1978, p.  
9-16.

MAJS: /\*ENERGY TECHNOLOGY/\*OCEAN THERMAL ENERGY CONVERSION/\*  
PROJECT PLANNING

MINS: / COST EFFECTIVENESS/ FUEL CELLS/ LIQUID AMMONIA/  
OCEAN SURFACE/ OFFSHORE ENERGY SOURCES/ TROPICAL  
REGIONS

ABA: G. R.

ABS: The term OTEC describes a method for generating power  
by using the warm water at the surface of the tropical  
oceans, in combination with the cold water available  
at a depth of half a mile, to operate a heat engine. A  
description is given of an optimized OTEC-ammonia-fuel  
cell system which could deliver base-load electric  
power to the user at a cost averaging about 30  
mills/kWh (in 1975 dollars). The system can deliver  
not only base-load power but, if adequate fuel cell  
capacity is provided, can also deliver  
intermediate-load power at approximately 33 mills/kWh  
and peak power at 50 to 60 mills/kWh on demand. It is  
found that OTEC-ammonia-electric power promises to  
compete favorably in cost with other options and can  
provide a future basis beginning by 1990 for an energy  
economy primarily based on OTEC ammonia that will be  
stable in price and available on an equal basis to the  
whole world.

#### SYSTEMS ASPECTS OF OCEAN THERMAL ENERGY CONVERSION.

R.H. Douglass, Jr. and P.J. Bakstad.

J. Hydronautics, v.12, no.1, Jan.1978, p.18-23.

Our studies indicate that economic viability of OTEC  
plants may be achieved through engineering development  
within a decade. Since OTEC plants may be constructed in  
quantity to a standard design, their potential for deployment  
in such numbers as to significantly augment the national  
energy supply by the year 2000 is enhanced. This paper deals  
with two related aspects of OTEC system development: the  
potential for application of classical system engineering and  
management techniques and the incentive to advance OTEC  
technology.

79A18109 ISSUE 5 PAGE 808 CATEGORY 44 78/00/00  
12 PAGES UNCLASSIFIED DOCUMENT

UTTL: OTEC in Europe --- economic aspects of Ocean Thermal  
Energy Conversion

AUTH: A/GRIEKSPoor, W.; B/VAN DER POT, B. J. G. PAA:  
A/(Tebodin Consulting Engineers, Netherlands);

B/(Hollandsche Beton Maatschappij, Netherlands)

In: International Symposium on Wave and Tidal Energy,  
Canterbury, England, September 27-29, 1978.  
Proceedings, Volume 1. (A79-18101 05-44) Cranfield,  
Beds., England, British Hydromechanics Research  
Association Fluid Engineering, 1978, p. D2-11 to  
D2-22.

MAJS: /\*ECONOMIC ANALYSIS/\*OCEAN THERMAL ENERGY CONVERSION/\*  
OFFSHORE ENERGY SOURCES

MINS: / COST ESTIMATES/ COST REDUCTION/ ELECTRIC POWER  
PLANTS/ ENERGY TECHNOLOGY/ INTERNATIONAL COOPERATION/  
LIQUID AMMONIA/ PILOT PLANTS/ RESEARCH AND DEVELOPMENT  
/ TECHNOLOGICAL FORECASTING/ TEMPERATURE DISTRIBUTION/  
WORKING FLUIDS

ABA: P.T.H.

ABS: The European study group on ocean thermal energy  
conversion (OTEC) aims at a 25 Mwe pilot demonstration  
plant before 1985. Their current objectives include  
(1) estimate the cost of electricity produced by a  
100-Mwe commercial off-shore OTEC plant, and (2)  
decide on a method of selecting, for a given site, the  
best combination of possible outlets of produced  
energy. A cost estimate is performed for a 100-Mwe  
offshore OTEC plant on the basis of design data  
including: (1) warm water at 25 C and cold water at 5  
C at 600 m below sea level, (2) flows of order of 500  
cu m/sec, (3) closed cycle turbine system with ammonia  
as working fluid, and (4) a floating structure.  
Economic analysis is based on 100 MW net output at the  
busbar, 30-year lifetime, and availability of 8000  
hr/yr.

A79-45595 Hydrogen and alternative means of energy  
delivery from ocean thermal energy conversion (OTEC) plants. A.  
Talib, A. Konopka, N. Biederman, C. Blazek, and B. Yudow  
(Institute of Gas Technology, Chicago, Ill.). In: Hydrogen for energy  
distribution; Proceedings of the Symposium, Chicago, Ill., July  
24-28, 1978. (A79-45576 20-44) Chicago, Institute of Gas Tech-  
nology, 1979, p. 399-423. 25 refs. NSF Grants No. NSF-C-1008;  
Grant No. AER-75-00033; Contract No. E-19-181-2426.

In the present paper, a concise technical assessment and  
economic analysis are made of components associated with the  
conversion, storage, transportation, and shore-based receiving facili-  
ties for the conversion of OTEC mechanical energy to chemical  
energy and, in some cases, conversion of delivered chemical energy to  
electricity. Particular attention is given to the equipment, capital and  
operating costs, and efficiencies of converting the delivered hydrogen  
and ammonia into electricity. V.P.

79N11556# ISSUE 2 PAGE 209 CATEGORY 44 RPT#:  
PB-283104/8 OTA-0-62 LC-78-60053 78/05/00 50 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Renewable ocean energy sources. Part 1: Ocean thermal energy conversion  
CORP: Office of Technology Assessment, Washington, D. C.  
AVAIL NTIS SAP: HC A03/MF A01  
MAJS: /\*ENERGY POLICY/\*HEAT SOURCES/\*OCEAN THERMAL ENERGY CONVERSION  
MINS: / ECONOMIC FACTORS/ ELECTRIC GENERATORS/ OPERATIONAL PROBLEMS/ PROJECT PLANNING/ TECHNOLOGY ASSESSMENT/ TEMPERATURE GRADIENTS  
ABA: GRA  
ABS: The current status of OTEC technology is reported, with particular attention to areas in which significant problems exist. The economic considerations which are pertinent to an OTEC system are discussed, and economic problems facing some of the products most often suggested for OTEC production are outlined. The present and possible future Government role in funding OTEC research is reported.

**N79-28749#** Ocean Systems, Inc., Reston, Va.  
**OTEC PLATFORM CONFIGURATION AND INTEGRATION STUDY. VOLUME 1: SYSTEMS ENGINEERING AND INTEGRATION** Final Report  
Apr. 1978 315 p refs  
(Contract EC-77-C-01-4063)  
(DOE/ET/4063-1-Vol-1: LMSC-D623756-Vol-1) Avail: NTIS HC A14/MF A01

The economic success of an ocean thermal energy conversion (OTEC) system is highly dependent on a platform which provides adequate support for the power system, accommodates reliably the cold water pipe, and is most cost effective. The results of a study conducted for the Department of Energy to assess six generic types of platforms to determine the most satisfactory platform for several potential sites are presented. The six platform configurations are ship, circular barge, semi-submersible, tuned sphere, submersible, and spar. These represent directional and symmetric types of platforms which operate on the surface, at the interface, and submerged. The five sites for this study were primarily New Orleans, Keshole Point (Hawaii), Brazil, and secondarily Key West and Puerto Rico. Electrical transmission of energy by submarine cable is the planned form of energy transmission for all sites except Brazil, where chemical conversion is to be the method of transmission. This study is devoted to the platform (or ocean systems) of the OTEC plant which is chiefly comprised of the hull and structure, the seawater system, the position control system, and miscellaneous support/assembly systems. The principal elements in the work breakdown structure for the commercial plants are presented. The assessment of the six platform configurations was conducted utilizing a baseline plan (100-MW(e) (Net)) and site (New Orleans) with variations from the baseline to cover the range of interested platforms and sites.  
DOE

79N11557# ISSUE 2 PAGE 209 CATEGORY 44 RPT#:  
PB-283103/0 OTA-0-63 78/05/00 127 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Renewable ocean energy sources. Part 1: Working papers. Ocean thermal energy conversion  
CORP: Office of Technology Assessment, Washington, D. C.  
AVAIL NTIS SAP: HC A07/MF A01  
MAJS: /\*ENERGY POLICY/\*HEAT SOURCES/\*OCEAN THERMAL ENERGY CONVERSION  
MINS: / ECONOMIC FACTORS/ ELECTRIC GENERATORS/ ENVIRONMENT EFFECTS/ OPERATIONAL PROBLEMS/ RESOURCES/ SITES/ TECHNOLOGY ASSESSMENT/ TEMPERATURE GRADIENTS  
ABA: GRA  
ABS: The discussions of the historical development of the OTEC concept (including the open-, closed-, and low temperature difference cycles), the resource potential of ocean thermal gradients, markets and products for OTEC, development status and technical problem areas are reported. Economic factors and environmental concerns are also treated. The shore-based and open-ocean OTEC sites are presented.

**USE OF CHLORINE TO CONTROL OTEC BIOFOULING**, by  
James A. Fava and David L. Thomas.  
Ocean Engineering, vol. 5, no. 4, August 1978, p.269-288.

**Abstract**—The applicability of chlorine to control Ocean Thermal Energy Conversion (OTEC) biofouling was investigated.

Onsite hypochlorite generation was found to be the preferred method of chlorination. The major fouling organisms of concern to OTEC are the microfouling organisms, that is, initial slime layers. However, macrofouling organisms may become a problem after several years of plant operation. Continuous low-level chlorination is more effective against hard-shelled macrofouling organisms and soft-shelled organisms, whereas intermittent chlorination will control slimes and soft-shelled organisms.

Actual on-site experimentation is needed before effective doses and chlorination regimes can be recommended. The doses and regimes may vary depending upon whether the condenser and/or evaporator heat exchangers are chlorinated.

**N80-14884#** Miami Univ., Coral Gables, Fla. Clean Energy Research Inst.  
**FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE. VOLUME 3, SECTIONS 6-7**  
A. Levi, ed. (DOE, Washington, D.C.) and T. N. Veziroglu, ed.  
Sep. 1978 520 p refs Conf. held at Miami Beach, Fla., 20-22 Feb. 1978  
(Grant EG-77-G-05-5550)  
(CONF-780236-P3) Avail: NTIS HC A22/MF A01

The ocean engineering aspects of the ocean thermal energy conversion (OTEC) program are discussed. Economic and commercialization topics are addressed. Topics include the power system development, the heat exchanger system, alternate power cycles, and biofouling and corrosion effects on the the cold water pipe system.  
A.W.H.

79N11531# ISSUE 2 PAGE 206 CATEGORY 44 RPT#:  
DOE/EDP-006 78/03/00 48 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Environmental Development Plan (EDP): Ocean thermal energy conversion, 1977  
CORP: Department of Energy, Washington, D. C. AVAIL:NTIS  
SAP: HC AG3/MF A01  
MAJS: /\*ENERGY POLICY/\*ENVIRONMENT EFFECTS/\*OCEAN THERMAL ENERGY CONVERSION  
MINS: / CLIMATOLOGY/ ECONOMIC FACTORS/ ENVIRONMENT POLLUTION / OCEAN CURRENTS/ WORKING FLUIDS  
ABA: DOE  
ABS: The status and goals of the OTEC program are described. Potential environmental, health, safety, and socioeconomic impacts relevant to OTEC are identified. These impacts are screened for key issues, i.e., those which are considered to be most serious in nature, which have near-term importance to the program, and for which current knowledge of effects and control strategies is inadequate. A management plan is presented for conducting and coordinating environmental research in concert with the technology development effort. This will ensure that identified environmental issues are resolved prior to significant public utilization of OTEC systems. The nine key issues associated with OTEC deployment are: ocean water mixing; metallic discharges; impingement/entrainment; use of biocides; working fluid leaks; climatological impacts; worker safety; international law; and secondary impacts.

78N14660# ISSUE 5 PAGE 650 CATEGORY 44 RPT#:  
CONF-770331-2 CNT#: W-7405-ENG-26 77/00/00 16  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Outline for optimizing and evaluating proposed OTEC systems  
AUTH: A/LYON, R. N.  
CORP: Oak Ridge National Lab., Tenn. AVAIL:NTIS SAP: HC AG2/MF A01  
Presented at 4th Ocean Thermal Energy Conversion Conf., New Orleans, 22 Mar. 1977  
MAJS: /\*ENERGY TECHNOLOGY/\*OCEAN THERMAL ENERGY CONVERSION  
MINS: / DIRECT POWER GENERATORS/ ENERGY CONVERSION/ OPTIMIZATION/ SYSTEMS ANALYSIS/ THERMAL ENERGY  
ABA: ERA  
ABS: The need to begin the development of a general modeling and optimization method for ocean thermal energy conversion systems for assistance in making a wide variety of administrative and design decisions is emphasized. Concepts that should be included in the model are outlined.

## OCEAN THERMAL ENERGY: THE BIGGEST GAMBLE IN SOLAR POWER.

W.D. Metz.

Science, v.198, Oct.14,1977, p.178-80.

Among the various systems proposed for utilizing solar energy, the largest and most complex one would use ocean water temperature differences to generate power.

Because the amount of energy that could be captured from the warm tropical oceans is truly phenomenal, the ocean thermal energy concept has many proponents. The ocean itself would be the collector and energy storage medi-

um, eliminating the need for two of the costliest components of land-based solar thermal systems. Drawing in warm water from the surface and cold water from the depths, an ocean thermal plant could operate continuously 24 hours per day. For this reason, the ocean thermal concept has often been characterized as the only sort of solar system with the potential to provide base-load power.

79A28922 ISSUE 11 PAGE 2056 CATEGORY 44  
77/12/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Optimum power plant capacity of ocean-based ocean thermal energy conversion systems  
AUTH: A/KAJIKAWA, T.; B/AGAWA, T.; C/HOMMA, T. PAA: C/(Ministry of International Trade and Industry, Electrotechnical Laboratory, Tokyo, Japan)  
Electrical Engineering in Japan, vol. 97, Nov.-Dec. 1977, p. 74-81. Translation.  
MAJS: /\*ELECTRIC POWER PLANTS/\*ENERGY CONVERSION EFFICIENCY /\*OCEAN THERMAL ENERGY CONVERSION/\*RANKINE CYCLE/\* SYSTEMS ENGINEERING  
MINS: / CLOSED CYCLES/ ENERGY TECHNOLOGY/ ENTROPY/ OPTIMIZATION/ THERMODYNAMIC EFFICIENCY  
ABA: S.D.  
ABS: A procedure is proposed to optimize the ocean thermal energy conversion plant capacity on the basis of performance evaluation by the heat transfer area of heat exchanger per net generated output power. This optimization process is illustrated by the example of a plant with total output capacity of 100 MW (working fluid NH<sub>3</sub>). Temperature and pump power allocations and the required dimensions of the optimal plant are derived. Pump powers required for intake of warm and cold water are expressed in terms of water velocity and friction factor. The plant capacity is varied from 1000 MW to 1 MW, and the effects of various factors on plant capacity and generation cost are analyzed. The evaluation function is strongly dependent on the temperature of warm water.



# DESIGN OF AN OCEAN THERMAL ENERGY PLANT SHIP TO PRODUCE AMMONIA VIA HYDROGEN

G. L. Dugger and E. J. Franics  
Hydrogen Energy

Vol. 2, n. 3

p. 231-249

## OCEAN THERMAL ENERGY CONVERSION R&D.

Government R&D Reports, v.8, no.2, July 15, 1977,  
p.2-3.

**A78-33301** Annual Conference on Ocean Thermal Energy Conversion, 4th, University of New Orleans, New Orleans, La., March 22-24, 1977, Proceedings. Conference supported by the Energy Research and Development Administration; Contract No. EG-77-G-05-5363. Edited by G. E. Ioup (New Orleans, University, New Orleans, La.). New Orleans, University of New Orleans, 1977. 630 p. \$20. (For individual items see A78-33302 to A78-33352)

The OTEC conference is divided into the following sections: total systems, mission analysis, environmental and siting considerations, ocean engineering, heat exchangers, biofouling and corrosion, and alternative power cycles. Particular papers are presented on economic incentives for the commercialization of OTEC, the potential mariculture yield of OTEC plants, an estimate of the impact of OTEC operation on the vertical distribution of heat in the Gulf of Mexico, resource assessment of a high potential OTEC site near Puerto Rico, and some factors affecting the selection of OTEC plant platform/cold water pipe designs. Also considered are enhanced single-phase heat transfer for OTEC systems, primary biofouling films and OTEC heat exchangers, and the effects of sea water leakage on the performance of the ammonia cycle for OTEC plants. B.J.

**A79-34041** Major factors in OTEC power cycle design. J. M. Clinch (Argonne National Laboratory, Argonne, Ill.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4. (A79-34036 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1557-1569. 11 refs.

This paper provides an overview of those factors that are of importance in OTEC power cycle design. Both open and closed Rankine cycles are discussed in relation to their operation and reliability. Critical components in the closed Rankine ammonia vapor cycle are reviewed from the viewpoint of performance, cost, materials and maintenance. Estimates indicate that a trade-off exists between the parasitic pumping power requirements and heat exchanger performance. The need for operating the high capacity OTEC pumps and turbines at their maximum efficiency is also emphasized. (Author)

**A79-34038** An update of OTEC baseline design. P. A. Curto (Mitre Corp., METREK Div., McLean, Va.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4. (A79-34036 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1505-1519. 5 refs.

A review of ocean thermal energy conversion (OTEC) systems was conducted for the purpose of estimating OTEC costs and probable market penetration in U.S. energy markets. The Lockheed, TRW, and Applied Physics Laboratory concepts were examined. A generic OTEC grid-connected, floating, spar-buoy, fixed-position system concept was chosen as likely to be the most cost-effective of the configurations for which preliminary designs currently exist. An update of this OTEC generic design is presented along with cost estimates for each of the primary subsystems. B.J.

**A79-41810** Ocean thermal energy (L'énergie thermique des mers). A. Brin (Ministère de l'Industrie, Direction des Mines, Paris, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977. Proceedings. Volume 2. (A79-41801 17-44) Paris, Ministère de l'Industrie, 1978, p. 114-122. In French.

Among the means of solar energy utilization, the OTEC concept presents a number of advantages. These include the vast quantity of the basic resource, the large regional distribution, weak seasonal variation (making storage unnecessary), and the capability of using already developed technology. The prime disadvantage is that the low efficiency of the process will require the construction of plants on a vast scale. This paper briefly reviews open-cycle and closed-cycle OTEC operation and presents some technical data on OTEC plants. B.J.

**N77-30278\*** Energy Research and Development Administration, Washington, D.C. Ocean Systems Branch  
**OCEAN THERMAL ENERGY CONVERSION (OTEC)**  
Abraham Lavi In NASA Marshall Space Flight Center Proc. of the ASPE/MSFC Symp. on Eng. and Productivity Gains from Space Technol. May 1977 p. 87-94 (For primary document see N77-30273 21-31)  
Avail: NTIS HC A13/MF A01 CSCL 10A

OCEAN POWER: IS THE U.S. AFRAID OF IT.  
J.F. Judge.  
Gov't Executive, Dec. 1977, p.29-32.

*The energy area with the greatest potential is being saddled with meaningless backyard experimentation—when full scale prototyping will answer the questions once and for all.*

TJ Shin Technology and Research (STAR)  
163.2 Symposium, 2d, San Francisco, 1977.  
.855 Proceedings, held in conjunction with  
1977 the SAME spring meeting hosted by the  
OCEAN THERMAL ENERGY CONVERSION

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# OPTIMIZATION OF AN OCEAN THERMAL ENERGY CONVERSION SYSTEM Ocean Engineering, v. 4, no. 1, March 1977, p. 23-39.

Abstract—The optimum performance of a simple Rankine cycle ocean thermal energy conversion plant is investigated analytically. It is shown that the ratio of maximum net power output to heat exchanger surface area varies as  $H(\Delta t - t_0)^2$  where  $H$  describes the overall heat transfer properties of the evaporator and condenser,  $\Delta t$  is the temperature difference between the warm and cold sea water supplies, and  $t_0$  is a parameter depending primarily upon the pressure drops across the warm and cold sea water pumping systems. The model is relatively insensitive to the choice of working fluid, although ammonia is used as the illustrative example.

VEN33575# ISSUE 24 PAGE 3239 CATEGORY 44 RPT#:  
ALO-3723-76/3 CNT#; E7-76-S 04-3723 77/12/31 132  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Open cycle ocean thermal energy conversion: A  
preliminary engineering evaluation  
AUTH: A/WATT, A. D.; B/MATHEWS, F. S.; C/HATHAWAY, R. E.  
CORP: Colorado School of Mines, Golden. CSS: (Dept. of  
Engineering Physics.) AVAIL: NTIS SAP: HC A07/MF  
A01  
MAJS: /ENERGY POLICY/OCEAN THERMAL ENERGY CONVERSION/  
TECHNOLOGY ASSESSMENT  
MINS: / COST ANALYSIS/ ENERGY TECHNOLOGY/ SYSTEMS  
ENGINEERING/ TURBINES/ WATER TEMPERATURE  
ABA: ERA  
ABS: The following subjects are covered: physical  
environment, system layout, warm water loop,  
turbine/generator, cold water loop, system performance  
and cost, and areas of major uncertainty.

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Offshore and underground power plants.  
Robert Noyes, Ed.  
Noyes Data Corp. 1977.

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## HOW HOT IS SOLAR ENERGY?

Environmental Science and Technology, vol. 11,  
no. 7, July 1977, p. 651 - 654

Today, not as hot as some think, but ocean thermal  
is heating up



UTTL: Interpretation of oceanographic data for the design of ocean thermal energy conversion plants

AUTH: A/LEWIS, L. F.; B/MAVOR, J. W., JR. PAA: A/(U.S. Department of Energy, Washington, D.C.); B/(Woods Hole Oceanographic Institution, Woods Hole, Mass.)  
In: Oceans '77: Annual Combined Conference, 3rd, Los Angeles, Calif., October 17-19, 1977. Conference Record, Volume 2. (A78-49651 22-48) New York, Institute of Electrical and Electronics Engineers, Inc.; Washington, D.C.; Marine Technology Society, 1977, p. 41B-1 to 41B-7. ERDA-supported research.

MAJS: /\*DESIGN ANALYSIS/\* ELECTRIC POWER PLANTS/\*OCEAN THERMAL ENERGY CONVERSION/\*OCEANOGRAPHIC PARAMETERS/\*OFFSHORE PLATFORMS/\*STRUCTURAL DESIGN CRITERIA

MINIS: / BIOLOGICAL EFFECTS/ ENERGY TECHNOLOGY/ FOULING/ OCEAN CURRENTS/ SEA STATES/ WATER TEMPERATURE/ WATER WAVES

ABA: B.J.

ABS: The design of an OTEC plant requires oceanographic measurements at the specific site to a fine degree of detail over a time interval and with a frequency sufficient to assure optimum configuration and performance. A part of the design process is the continuous evaluation of the oceanic data and matching it to the needs of design, construction, and test. The present paper describes a program underway to assess available ocean data (pertaining to such parameters and phenomena as temperature, extreme events, waves, internal waves, biofouling, and corrosion and erosion), to design a plan and schedule to match ocean data to OTEC design, to match existing data to this plan, and to recommend a program of additional measurements.

TJ Bereny, Justin A.

310 Survey of the emerging solar energy industry / compiled and written by Justin A.  
.B46 Bereny ; edited by Francis deWinter. --  
1977 1977 ed. -- San Mateo, Calif. : Solar Energy Information Services, c1977.  
xi, 405 p. : ill. ; 28 cm.  
Bibliography: p. 369-377.

XI. OCEAN THERMAL ENERGY CONVERSION. *P.183-199.*

TJ New options in energy technology / sponsored  
163.2 by the American Institute of Aeronautics and  
.N47 Astronautics, Edison Electric Institute, IEEE  
Power Engineering Society. -- New York :  
American Institute of Aeronautics and Astro-  
nautics, c1977.

149 p. : ill. ; 29 cm.

Papers nos. 77-1004-771034

Includes bibliographical references.

1. Power resources--Research--Congresses.

Perspectives on Implementing OTEC Power - D. G. JOPLING....*P.9.P.*.....

ABS: Major problems confronting the development and commercialization of ocean thermal energy conversion (OTEC) are discussed, along with OTEC feasibility. The need for large extended heat exchangers and the high cost of such exchangers is focused on as a major problem, along with problems of corrosion and marine microbiofouling of the heat exchanger and other system equipment. Open or closed cycles, anchoring or sea surface grazing, component construction and assembly on the high seas, mooring during setup, and mechanical stresses at anchorage or en route to location are discussed. Advanced turbine and pump designs, bottoming cycles, new construction materials and techniques, and new heat transfer fluids and heat exchangers designs are envisaged as likely technological spinoffs from OTEC.

TK Conference on Ocean Thermal Energy Conversion,  
1056 4th, University of New Orleans, New Orleans,  
.C65 Louisiana, 1977.

1977 Proceedings : fourth annual Conference on  
Ocean Thermal Energy Conversion, University  
of New Orleans, New Orleans, Louisiana,  
70122, March 22-24, 1977 / George E. Ioup,  
editor ; supported by : the Division of  
Solar Energy, U.S. Energy and Development  
Administration. -- [s.l. : s.n.], 1977.  
631 p. in various pagings : ill.

TJ 163.2 .G74 1977	Greater Los Angeles Area Energy Symposium, 1977. Greater Los Angeles Area Energy Symposium: Tuesday, April 26, 1977 ... Los Angeles, California / sponsored by the Los Angeles Council of Engineers and Scientists, under the auspices of the Los Angeles Section of the American Nuclear Society ... [et al. ;	
	Thermal Gradient-Hydro Generation Cycle Sidney A. Parker, 21st Century Power Generation Company	131
	Ocean Thermal Energy Conversion (OTEC) Status and Prospects J. Edward Snyder, TRW Systems	137
K 3984 .A44	Ocean thermal energy conversion : legal, political, and institutional aspects / edi- ted by H. Gary Knight, J. D. Nyhart, Robert E. Stein. — Lexington, Mass. : Lexington Books, c1977. Ocean Thermal Energy Conversion (OTEC) Plants: Technical Background Herman E. Sheets An Economic Assessment of Ocean Thermal Energy Conversion Carlos D. Stern International Jurisdictional Issues Involving OTEC Installations H. Gary Knight International Political Implications of Ocean Thermal Energy Conversion Systems Ann L. Hollick Spatial and Emerging Use Conflicts of Ocean Space Byron Washom International Regulatory Authority Concerning Ocean Thermal Energy Conversion Devices C.R. Hallberg	1 25 45 75 91 109

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Ocean Thermal Energy Conversion Plants: Federal and State Regulatory Aspects James C. Higgins, Jr.	165
Ocean Thermal Energy Conversion: Domestic Environmental Aspects Thomas B. Stoel, Jr.	195
Legal Aspects of Financing Ocean Thermal Energy Plants John H. Riggs, Jr.	203

78A11110 ISSUE 1 PAGE 61 CATEGORY 44 77/00/00  
6 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Feasibility of integrated ocean thermal  
gradient-nuclear plants for the production of  
electrical power  
AUTH: A/FERRER, F.; B/SASSCER, D. PAA: B/(University of  
Puerto Rico, Mayaguez, P.R.)  
In: Energy crisis: An evaluation of our resource  
potential; Proceedings of the Third Annual UM -NEC  
Conference on Energy, Rolla, Mo., October 12-14, 1976.  
(A78-11089 01-44) North Hollywood, Calif.: Western  
Periodicals Co., 1977, p. 611-616  
MAJS: /ELECTRIC POWER PLANTS/ ENERGY CONVERSION EFFICIENCY  
/FEASIBILITY ANALYSIS/ NUCLEAR POWER PLANTS/ OCEAN  
THERMAL ENERGY CONVERSION/ WASTE ENERGY UTILIZATION  
MINS: / COST EFFECTIVENESS/ OFFSHORE ENERGY SOURCES/ SYSTEMS  
ENGINEERING/ THERMODYNAMIC EFFICIENCY/ WATER DEPTH  
ABA: (Author)  
ABS: A study was made of the feasibility of integrating an  
ocean thermal energy conversion (OTEC) electrical  
power plant with a nuclear power plant. The  
integration was such that the waste heat of the  
nuclear plant was used to augment the thermal  
efficiency of the OTEC plant. The study was performed  
for three shore line sites of Puerto Rico where deep  
cold water is found between 2 and 10 miles from shore.

# THE OTEC ANSWER TO OPEC: SOLAR SEA POWER! Clarence Zener

Mechanical Engineering, June 1977, vol. 99,  
no. 6, p. 26-29

**ABS:** It has been estimated that the top isothermal layer of the tropical ocean has an 'effective head' of 960 ft. Current research projects involving Ocean Thermal Energy Conversion systems making use of this work potential are briefly described. A new type of OTEC system in which all warm water input serves as a working medium and is discarded at the same temperature as the discard of the cold water input is outlined. The seawater is foamed using a biodegradable surfactant; the tight mechanical coupling between the water vapor in a single foam cell and the liquid in its surrounding walls forms the basis of the system. The vapor and its share of the enclosing liquid move isentropically from the saturation vapor pressure for 25 C to the saturation vapor pressure for 5 C water, liberating a work potential of 2.87 J/g.

78N21652# ISSUE 12 PAGE 1603 CATEGORY 44 RPT#:  
ORAU/IEA(M)-77-1 CNT#: EY-76-C-05-0033 77/02/00  
55 PAGES UNCLASSIFIED DOCUMENT

**UTTL:** Net energy analysis of an Ocean Thermal Energy Conversion (OTEC) system

**AUTH:** A/PERRY, A. M.; B/MARLAND, G.; C/ZELBY, L. W.  
**CORP:** Institute for Energy Analysis, Oak Ridge, Tenn.  
AVAIL NTIS SAP: HC A04/MF A01

**MAJS:** /\*ENERGY REQUIREMENTS/\*OCEAN THERMAL ENERGY CONVERSION  
**MINS:** / ALUMINUM ALLOYS/ CORROSION RESISTANCE/ COST  
EFFECTIVENESS/ RANKINE CYCLE

**ABA:** ERA

**ABS:** The system used a Rankine power cycle with ammonia as the working fluid, and was based on essentially available technology. The plant would be located about 20 miles offshore and would produce 160 MW(e) of net electricity which would be carried ashore by underwater cable for transmission and distribution by conventional means. Evaporators and condensers for the ammonia power cycle were assumed to be made of titanium (for resistance to corrosion) although it was recognized that aluminum alloys-preferable from a cost standpoint-would prove to have acceptable corrosion resistance. Net electrical output of the plant at an assumed 90% plant factor was  $1.26 \times 10$  to the 9th kWh(e) per year.

77A38446 ISSUE 17 PAGE 2910 CATEGORY 44

77/07/07 6 PAGES UNCLASSIFIED DOCUMENT

**UTTL:** Sea water - The energy elixir --- ocean thermal, tide and wave energy conversion

**AUTH:** A/ZIMMERMAN, M. D.

Machine Design, vol. 49, July 7, 1977, p. 20-22, 24-26.

**MAJS:** /\*ENERGY TECHNOLOGY/\*OCEAN THERMAL ENERGY CONVERSION/\*  
OFFSHORE ENERGY SOURCES/\*SOLAR SEA POWER PLANTS/\*TIDE  
POWERED GENERATORS/\*WATERWAVE ENERGY CONVERSION

**MINS:** / OCEAN SURFACE/ RESEARCH AND DEVELOPMENT/ TIDEPOWER/  
WATER WAVES

**ABA:** G.R.

**ABS:** Approaches for utilizing the energy stored in the oceans are considered. One approach is based on the utilization of the difference between the temperature of the water at the ocean surface and the temperature of deep-ocean waters. The approach is to employ a working fluid that boils and condenses at small temperature differences, like ammonia, to establish a closed power-conversion cycle. Other approaches considered are to make use of the moon-driven tides, the power of wind-swept waves, or the energy which can be released from the mixing of freshwater with saltwater. Attention is also given to a number of unresolved issues concerning ocean-energy systems.

78N18568# ISSUE 9 PAGE 1183 CATEGORY 44 RPT#:

PB-274123/9 ISBN-0-669-01441-9 NSF/RA-770273

LC-77-2049 CNT#: NSF AER-75-00280-A02 77/00/00  
255 PAGES UNCLASSIFIED DOCUMENT

**UTTL:** Ocean thermal energy conversion: Legal, political, and institutional aspects

**AUTH:** A/KNIGHT, H. G.; B/NYHART, J. D.; C/STEIN, R. E.  
PAT: A/ed.; B/ed.; C/ed.

**CORP:** American Society of International Law, Washington, D. C.  
AVAIL NTIS SAP: MF A01

**MAJS:** /\*SOLAR ENERGY CONVERSION/\*THERMAL ENERGY

**MINS:** / ENERGY TECHNOLOGY/ INTERNATIONAL LAW/ LAW  
(JURISPRUDENCE)

**ABA:** GRA

**ABS:** An overview of nonlegal issues, including the technical background of OTEC plants and an economic assessment of OTEC are presented. Also presented is an evaluation of the international legal aspects; international political implications of OTEC systems; spatial and emerging use conflicts of ocean space; international regulatory authority concerning OTEC devices; and international environmental aspects.



TI Solar thermal and ocean thermal : joint conference, American Section, International  
 810 Solar Energy Society and Solar Energy Society of Canada, Inc., August 15-20, 1976,  
 .S48 v.5 Winnipeg / editor, K. W. Boer. -- Cape

OCEAN THERMAL

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77A49018 ISSUE 23 PAGE 4006 CATEGORY 44

76/00/00 37 PAGES UNCLASSIFIED DOCUMENT

UTTL: Technical and economic feasibility of Ocean Thermal Energy Conversion

AUTH: A/DUGGER, G. L.; B/FRANCIS, E. J.; C/SMERY, W. H.

PAA: C/(Johns Hopkins University, Laurel, Md.)

In: Sharing the sun: Solar technology in the seventies: Proceedings of the Joint Conference, Winnipeg, Canada, August 15-20, 1976, Volume 5, (A77-48910 23-44) Cape Canaveral, Fla.: International Solar Energy Society, 1976, p. 9-45. Research supported by the U.S. Maritime Administration and ERDA.

MAJS: /\*CONFERENCES/\*ECONOMIC ANALYSIS/\*ELECTRIC POWER PLANTS/\*ENERGY SOURCES/\*FEASIBILITY ANALYSIS/\*OCEAN THERMAL ENERGY CONVERSION

MINS: / COST EFFECTIVENESS/ ENERGY TECHNOLOGY/ MARINE ENVIRONMENTS/ RANKINE CYCLE/ SHIPS/ SOLAR ENERGY CONVERSION/ SOLAR HEATING

ABA: (Author)

ABS: Ocean Thermal Energy Conversion (OTEC) plants will employ the temperature difference between the solar-heated surface layer of a tropical ocean (24 to 28 C) and the water at 500 to 1200 m depth (4 to 7 C) as the source and sink for a Rankine cycle system to generate electric power. The first commercial plants could be deployed in the mid-1980s, and we believe they will be competitive then with fossil fuel and nuclear energy sources for selected applications. Ammonia (for fertilizers) is a particularly attractive product, because 95% of the ammonia produced in the U.S. is now made from natural gas, our scarcest resource. Direct delivery of electric power to shore may also be competitive for, e.g., the southeastern United States. In the 1990s, delivery of liquid hydrogen and many other products should become attractive. Various OTEC plant-ship concepts, their economics, onboard production plants, and some of the environmental considerations are discussed.

# OCEAN - HYDROELECTRIC (INCLUDING TIDAL)

## 14291 TIDAL ENERGY INTEGRATION WITH PUMPED STORAGE

KEY WORDS: Canada; Dynamic programming; Hydroelectric power; Maine; Pumped storage; Tidal energy; Tidal power plants

ABSTRACT: This paper shows how the value of tidal energy is enhanced when it is integrated into an electrical system using a pumped-storage scheme. An optimum operations policy for the combined tidal and pumped-storage schemes has been determined by a dynamic programming method. This objective has been demonstrated for a tidal energy scheme in the Minas Basin, Bay of Fundy, and a pumped-storage scheme on the St. John River, Maine — known as the Dickey-Lincoln School Lakes Project. It was assumed that the energy produced by both stations would be sold in a joint Maritime Provinces/New England electricity supply system. The paper concludes that optimally integrating the tidal energy in the way described leads to an increase in the value of the tidal energy to the system of 9% in an average water year.

REFERENCE: Gibson, Robert Anthony, and Wilson, Eric Montgomery, "Tidal Energy Integration Using Pumped Storage," *Journal of the Energy Division, ASCE*, Vol. 105, No. EY1, Proc. Paper 14291, January, 1979, pp. 71-80

A79-37865 Influence of technological advances on potential tidal power development. R. Tanner, J. G. Warnock (Acres Consulting Services, Ltd., Canada), and D. Murphy (Fenco Consultants, Ltd., Toronto, Canada). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 130-142.

It is shown that tidal power development may benefit from several significant technological advances in the fields of civil, mechanical, and electrical engineering and proposed new energy storage and retiming methods. No single advance is likely to be overwhelming in economic impact and the necessary improvement in benefit/cost ratio for tidal power plants are likely to arise only from a well balanced application of a variety of new, existing, and future technologies. The scale of tidal power is usually large and the capital investment requirements very substantial. B.J.

1979

09916

79A33767 ISSUE 13 PAGE 2411 CATEGORY 44  
79/06/00 16 PAGES UNCLASSIFIED DOCUMENT

TTL: Design and experimental testing of a fully-submerged model wave-power converter

AUTH: A/KNOTT, G. F.; B/FLOWER, J. O. PAA: B/(Sussex, University, Brighton, England)  
International Journal of Energy Research, vol. 3, Apr.-June 1979, p. 157-172. Research supported by the Science Research Council.

MAJS: /\*ENERGY TECHNOLOGY/\*WATERWAVE ENERGY CONVERSION  
MINS: / PERFORMANCE TESTS/ SUBMERGED BODIES/ UNDERWATER STRUCTURES

ABA: (Author)

ABS: A new form of wave-power converter is described which operates entirely beneath the water surface. Its operating principles are derived from theories relating to immersed cylinders which predict that a substantial proportion of incident wave-power can be absorbed by such bodies if they are constrained to respond to the waves in a prescribed way. Here, a series of discrete pulsating sources distributed around the surface of a stationary cylindrical body are used to approximate the necessary bodily motion. A one-hundredth scale model has been built and tested in a wave-tank, and the results of these experiments are presented. They indicate that under optimum operating conditions most of the incident wave-power is absorbed by the device. However, little of this power appears as useful work owing to the frictional losses inherent in such a small-scale model. Further analysis of the data estimates the extent of the losses, and after taking these into account figures are arrived at for the optimal operation of the model in loss-less condition. This paper concludes with a discussion of the prospects for further development.



79A37858 ISSUE 15 PAGE 2789 CATEGORY 44  
79/00/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: Directly driven generators for wave energy conversion  
AUTH: A/JACKSON, R. J. PAA: A/(Central Electricity  
Generating Board, Research Laboratories, Leatherhead,  
Surrey, England)

In: International Conference on Future Energy  
Concepts, London, England, January 30-February 1,  
1979, Proceedings. (A79-37842 15-44) London,  
Institution of Electrical Engineers, 1979, p. 92-95.

MAJS: /\*DIRECT POWER GENERATORS/\*HOMOPOLAR GENERATORS/\*  
WATERWAVE ENERGY CONVERSION/\*WATERWAVE POWERED  
MACHINES

MINS: / BRUSHES/ ENERGY DISSIPATION/ ENERGY REQUIREMENTS/  
MAINTENANCE/ OUTPUT/ ROTOR SPEED/ VELOCITY  
DISTRIBUTION/ WAVE GENERATION

ABA: B.J.

ABS: It is found that a directly driven ac generator  
applied in a wave energy conversion system (a linked  
pontoon pair wave energy converter) would have high  
losses (typically 11% of the generator output) and be  
much larger than the equivalent fixed speed machine. A  
directly driven homopolar generator would have  
relatively low losses, less than 5% of the mean power  
output, but the reversal of the rotor at the wave  
frequency necessitates the use of carbon brushes which  
would require regular maintenance. A smart generator  
which provides a variable reaction torque proportional  
to the displacement velocity and acceleration of the  
wave energy converter pontoons will be the same size  
and have about the same losses as the conventional  
generator which provides a fixed velocity proportional  
torque.

A80-17136 The application potential of hydro power. E.  
J. Jeffs. (United Nations University, East West Center, International  
Institute for Applied Systems Analysis, and University of Hawaii,  
Conference on Non-Fossil Fuel and Non-Nuclear Fuel Energy  
Strategies, Honolulu, Hawaii, Jan. 9-12, 1979.) Energy (UK), vol. 4,  
Oct. 1979, p. 841-849. 6 refs.

The potential for the future application of hydroelectric power,  
the only renewable alternative energy source with already established  
large-scale technology, is discussed. The scenario of a totally electric  
energy society in which heat can be produced as a byproduct of  
electricity generation is presented, and means for the expansion of  
hydropower installations are considered. It is suggested that small  
hydro plants with capacities between 1 and 10 MW could be used to  
meet local energy demands, pumped storage may be used to  
accommodate peak demands and provide back-up energy storage,  
and hydropower potential can be exploited in remote regions and  
developing nations, possibly even by the exploitation of glacial  
run-off. The economic and political aspects of the development of an  
energy trade on the basis of new hydropower installations in remote  
regions are also considered. A.L.W.

79A37916 ISSUE 15 PAGE 2794 CATEGORY 44  
79/00/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Initial thoughts on the transmission implications of  
large wave power complexes

AUTH: A/MAYES, R. P.; B/EUNSON, E. M. PAA: B/(Central  
Electricity Generating Board, London, England)

In: International Conference on Future Energy  
Concepts, London, England, January 30-February 1,  
1979, Proceedings. (A79-37842 15-44) London,  
Institution of Electrical Engineers, 1979, p. 406-413.

MAJS: /\*ELECTRIC NETWORKS/\*ELECTRIC POWER TRANSMISSION/\*  
TRANSMISSION LINES/\*WATERWAVE ENERGY CONVERSION

INS: / COSTS/ ENERGY TECHNOLOGY/ ENGLAND/ EQUIPMENT  
SPECIFICATIONS/ OFFSHORE PLATFORMS

ABA: P.T.H.

ABS: The paper summarizes a study carried out to assess the  
technical problems and costs associated with  
connecting groups of wave power facilities to the  
national electrical grid of Great Britain. The wave  
power abstraction rate was taken as 60 kW/m and  
consideration was given to (1) a 600 MW group located  
20 km off-shore, which is 12 km long; (2) twenty  
600-MW groups 10-40 km off the Outer Hebrides and the  
west coast of Scotland over an arc of 350 km; and (3)  
three groups off the Hebrides, Berwick, and Lundy  
Isle, each 4 GW. Sensitivities and proportion of costs  
due to geographical locations are discussed in terms  
of total capacities and the off-shore and on-shore  
connection costs. A sample of some of the conclusions  
shows that there is no economy of scale for  
transmission costs with a 12 GW concentration of wave  
power generation off the Hebrides. Three distributed 4  
GW sites would show a saving of 66% and a single 2 GW  
group of Berwick would give a 92% saving in terms of  
specific costs

A79-37863 Tidal power - The path to production. B.

Severn and D. R. White. In: International Conference on Future  
Energy Concepts, London, England, January 30-February 1, 1979,  
Proceedings. (A79-37842 15-44) London, Institution of Electrical  
Engineers, 1979, p. 122-125.

The paper examines the perspective of tidal power studies which  
may lead to full project definition and firm decision whether to  
construct a selected project. The background and circumstances  
considered are primarily those of Severn Estuary and the UK for the  
mid-1978 period, though the underlying philosophy and much of the  
detail are of wider applicability. B.J.

79A45780# ISSUE 20 PAGE 3776 CATEGORY 44  
79/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Waves salinity gradients and ocean currents -  
Alternative energy sources

AUTH: A/MCCORMICK, M. E. PAA: A/(U.S. Naval Academy,  
Annapolis, Md.)

In: Ocean thermal energy for the 80's: Ocean Thermal  
Energy Conversion Conference, 6th, Washington, D.C.,  
June 19-22, 1979, Preprints, Volume 1. (A79-45776  
20-44) Laurel, Md., Johns Hopkins University, 1979, p.  
2B-1/1 to 2B 1/6.

MAJS: /\*ENERGY SOURCES/\*OCEAN CURRENTS/\*OCEAN THERMAL ENERGY  
CONVERSION/\*SALINITY/\*WATER WAVES

MINS: / ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY/  
ENVIRONMENT EFFECTS/ GRADIENTS/ TIDE POWERED  
GENERATORS

ABA: A.T.

ABS: Ocean wave, salinity gradients, and ocean current  
energy conversion techniques are reviewed. Cavity  
resonator and wave focusing systems of ocean wave  
energy conversion are considered, emphasizing radiant  
wave interaction, Fresnel-type focusing, and  
conversion channeling. The salinity gradient system  
uses osmosis or electrodialysis for converting the  
energy of mixing of high saline and low saline waters.  
Osmotic pressure conversion has the greatest energy  
potential, but its technology requirements are not yet  
ready. The reverse electrodialytic technology is  
available, and unlike osmosis, this method is not site  
dependent. A 75 MW ducted turbine supported around the  
periphery by liquid bearings is used to study the  
environmental effects, hydroelastic stability of the  
rotor blades and the mooring and anchoring systems in  
ocean current energy conversion.

79A37859 ISSUE 15 PAGE 2790 CATEGORY 44  
79/00/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: The absorption of energy from ocean waves

AUTH: A/COUNT, B. M. PAA: A/(Central Electricity  
Generating Board, Marchwood Engineering Laboratories,  
Marchwood, Surrey, England)

In: International Conference on Future Energy  
Concepts, London, England, January 30-February 1,  
1979, Proceedings. (A79-37842 15-44) London.

Institution of Electrical Engineers, 1979, p. 96-99.

MAJS: /\*ENERGY ABSORPTION/\*HYDRODYNAMICS/\*POWER EFFICIENCY/\*  
SEA WATER/\*WATER WAVES/\*WATERWAVE ENERGY CONVERSION

MINS: / ELECTRIC POWER TRANSMISSION/ ELECTROMECHANICAL  
DEVICES/ ENERGY REQUIREMENTS/ HYDRODYNAMIC EQUATIONS/  
LINEAR SYSTEMS/ OPTIMIZATION/ WATERWAVE POWERED  
MACHINES

ABA: B.J.

ABS: The paper examines the implications of linear wave  
theory for the optimization of the structure and power  
takeoff characteristics of wave power systems. Results  
are extended to accommodate realistic sea conditions  
and some unique engineering requirements are  
identified. Finally, the implications of nonoptimum  
mechanical conditioning are discussed along with areas  
where future development may be possible.

79A50400 ISSUE 22 PAGE 4186 CATEGORY 44  
79/09/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Exploiting wave power --- electric energy source from  
ocean waves

AUTH: A/COUNT, B. M. PAA: A/(Central Electricity  
Generating Board, Marchwood Engineering Laboratories,  
Southampton, England)  
IEEE Spectrum, vol. 16, Sept. 1979, p. 42-49.

MAJS: /\*ENERGY CONVERSION EFFICIENCY/\*ENERGY SOURCES/\*TIDAL  
WAVES/\*TIDE POWERED GENERATORS

MINS: / COASTAL WATER/ COST EFFECTIVENESS/ DESIGN ANALYSIS/  
ECONOMIC ANALYSIS/ ELECTRIC POWER PLANTS/ ENERGY  
TECHNOLOGY/ OCEAN SURFACE/ OCEAN THERMAL ENERGY  
CONVERSION/ PILOT PLANTS/ SYSTEMS ENGINEERING/ WATER  
WAVES

ABA: M.E.P.

ABS: A survey of proposed wave power systems is presented.  
Five power conversion devices are studied: (1) the  
Salter Duck - an asymmetric, cam-shaped device,  
oscillating about a fixed point, (2) the Cockerell  
Raft - a structure of rafts hinged together, (3) the  
air buoy - an asymmetric chamber with trapped water  
and air, (4) the Kamei - a Japanese device resembling  
an open bottom ship with 22 air chambers, and (5) the  
rectifier - structure of high level and low level  
reservoirs. Attention is given to the two basic types  
of devices dynamic and passive, and compared.  
Consideration is also given to such points as  
transmitting the power to shore, control philosophy  
for maximum power, and power vs torque. Finally,  
unsolved problems such as construction of a spine  
structure strong enough to survive extreme wave  
conditions are discussed.

79A37870 ISSUE 15 PAGE 2791 CATEGORY 44  
79/00/00 3 PAGES UNCLASSIFIED DOCUMENT

UTTL: Tidal current energy conversion

AUTH: A/WYMAN, P. R.; B/PEACHEY, C. J. PAA: B/(General  
Electric Co., Ltd., Hirst Research Centre, Wembley,  
Middx., England)

In: International Conference on Future Energy  
Concepts, London, England, January 30-February 1,  
1979, Proceedings. (A79-37842 15-44) London.

Institution of Electrical Engineers, 1979, p. 164-166.

MAJS: /\*ENERGY CONVERSION/\*TIDE POWERED MACHINES/\*TIDEPower  
MINS: / AXIAL FLOW TURBINES/ ELECTRIC POWER TRANSMISSION/  
ENERGY TECHNOLOGY/ OFFSHORE PLATFORMS/ TECHNOLOGY  
ASSESSMENT

ABA: B.J.

ABS: The paper considers a 'tide mill' concept involving  
extraction of energy from tidal currents by means of  
immersed rotors. The analogy with windmills can be  
drawn, with the difference that the tidal currents are  
predominantly bidirectional, so that an axial flow  
rotor which could accept reversal could be prealigned,  
and the cross flow rotor (Darrieus type) would lose  
one of its most important advantages. Tide mills are  
examined with reference to device design, generation  
and transmission, mooring and structures, and extent  
of available extractable energy.

79A37918 ISSUE 15 PAGE 2795 CATEGORY 44  
79/00/00 5 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Energy analysis of wave and tidal power  
AUTH: A/HARRISON, R.; B/SMITH, K. G.; C/VARLEY, J. S.  
PAA: C/(Sunderland Polytechnic, Sunderland, England)  
In: International Conference on Future Energy  
Concepts, London, England, January 30-February 1,  
1979, Proceedings. (A79-37842 15-44) London,  
Institution of Electrical Engineers, 1979, p. 422-426.  
MAJS: /\*ENERGY CONVERSION EFFICIENCY/\*ENERGY SOURCES/\*  
TIDEPOWER/\*WATERWAVE ENERGY CONVERSION  
MINS: / ENERGY TECHNOLOGY/ TIDE POWERED MACHINES/ WATERWAVE  
POWERED MACHINES  
ABA: P.T.H.

ABS: A methodology is developed for energy analysis of wave  
and tidal power based on the concepts of energy ratio  
defined as total output over lifetime of device  
divided by energy required to build the device or the  
output of the device over one year divided by energy  
requirements for one year's operation, and extraction  
efficiency, defined as total output of device over a  
season divided by total energy incident on the devices  
at that location. When applied to the Salter duck, the  
energy ratio analysis gives a figure of 13.1 for a  
duck made of concrete, which implies viability, but a  
ratio of 10.1 for a steel duck, which is probably not  
viable. For a Shaw two-basin tidal power system, it is  
clear that the energy requirement of construction will  
be a significant fraction of the barrage output, and  
that further work on energy analysis is justified.

79A37862 ISSUE 15 PAGE 2790 CATEGORY 44  
79/00/00 4 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Tidal and river current energy systems  
AUTH: A/FRAENKEL, P. L.; B/MUSGROVE, P. J. PAA:  
A/(Intermediate Technology Development Group, Reading,  
Berks., England); B/(Reading University, Reading,  
Berks., England)  
In: International Conference on Future Energy  
Concepts, London, England, January 30-February 1,  
1979, Proceedings. (A79-37842 15-44) London,  
Institution of Electrical Engineers, 1979, p. 114-117.  
Research supported by the Hilden Charitable Fund.  
MAJS: /\*ENERGY SOURCES/\*RIVERS/\*TIDEPOWER/\*WATER CURRENTS  
MINS: / ELECTRIC GENERATORS/ ENERGY TECHNOLOGY/ TIDE POWERED  
GENERATORS/ TURBOGENERATORS/ UNITED KINGDOM  
ABA: B.J.

ABS: It is suggested that tidal streams and river currents  
provide a high density power source that could  
contribute significantly to the energy needs of many  
countries. Even large tidal stream power systems would  
have a modest development cost and could be speedily  
deployed in modular form as their economics warranted.  
Both for river currents and tidal streams, the  
vertical axis Darrieus rotor provides a simple means  
of harnessing the energy present as has been  
demonstrated by a small scale experimental program.

79A14719 ISSUE 3 PAGE 421 CATEGORY 44 78/00/00  
28 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Wind, waves, and tides --- as future energy sources  
AUTH: A/MERRIAM, M. F. PAA: A/(California, University,  
Berkeley, Calif.)  
In: Annual review of energy, Volume 3. (A79-14718  
03-44) Palo Alto, Calif., Annual Reviews, Inc., 1978,  
p. 29-56.

MAJS: /\*ENERGY SOURCES/\*TECHNOLOGICAL FORECASTING/\*TIDEPOWER  
/\*WATERWAVE ENERGY CONVERSION/\*WINDPOWER UTILIZATION  
MINS: / COSTS/ ECONOMIC FACTORS/ ENERGY POLICY/ ENERGY  
TECHNOLOGY/ FEASIBILITY/ HISTORIES/ POWER EFFICIENCY/  
WINDMILLS (WINDPOWERED MACHINES)

ABA: G.R.  
ABS: Wind, waves, and tides are of interest today as  
possible future energy sources primarily because of  
their nondepletable character and their favorable  
environmental aspect, in comparison with energy  
technologies presently in use. Studies comparing the  
cost of energy often have difficulties making a case  
for immediate economic viability of the renewable  
sources. If, however, oil and gas resources of the  
world do in fact become progressively and  
substantially depleted over the next 25 years, price  
increases and shortages will ensue and implementation  
of presently uneconomic alternatives will occur on a  
large scale. A review is presented of the present  
state of knowledge and experience with wind, wave, and  
tidal energy. The power density in the wind may, at a  
good site, average some hundreds of watts per square  
meter, wave power being transported across a plane  
perpendicular to the wave propagation direction, at a  
good site, is from 10 to 100 times as large. Questions  
concerning the value of energy from an intermittent  
source are also considered.

79N14581# ISSUE 5 PAGE 623 CATEGORY 44 RPT#:  
PB-286571/3 C10-78/2 NOAA-78082203 78/08/00 15  
PAGES UNCLASSIFIED DOCUMENT  
UTTL: Harnessing tidal energy  
CORP: National Oceanic and Atmospheric Administration,  
Washington, D. C. AVAIL:NTIS SAP: HC A02/MF A01  
MAJS: /\*ELECTRIC GENERATORS/\*ENERGY CONVERSION EFFICIENCY/\*  
ENERGY POLICY/\*TIDE POWERED GENERATORS  
MINS: / CONSTRAINTS/ ELECTRIC POWER TRANSMISSION/ HARNESSSES/  
HYDROELECTRIC POWER STATIONS

ABA: GRA  
ABS: About 3,000,000 megawatts (MW) of power are  
continuously dissipated through the motion of the  
tides over the surface of the earth. Due to physical  
limitations, only 2 percent of this may ever be  
harnessed. This amounts to about 5 percent of the  
present worldwide power generation from all sources.  
This inexhaustible power source can make a small, but  
significant, contribution. The background and  
fundamental principles of tidal power are discussed  
and recent developments are given. A selected listing  
of some of the published material relating to  
electrical power generation from tides is included.



79A18102 ISSUE 5 PAGE 867 CATEGORY 44 78/00/00  
6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Tidal power plants - Sites, history and geographical distribution

AUTH: A/CHARLIER, R. H. PAA: A/(Northeastern Illinois University, Chicago, Ill.; Brussels, Free University, Brussels, Belgium)

In: International Symposium on Wave and Tidal Energy, Canterbury, England, September 27-29, 1978.

Proceedings, Volume 1. (A79-18101 05-44) Cranfield,

Beds., England, British Hydromechanics Research

Association Fluid Engineering, 1978, p. A1-1 to A1-6.

MAJS: /\*CLEAN ENERGY/\*ELECTRIC POWER PLANTS/\*SITES/\*TIDE POWERED GENERATORS

MINS: / APPROPRIATIONS/ ECONOMIC FACTORS/ ENERGY TECHNOLOGY/ GEOGRAPHY/ HISTORIES/ MILLING MACHINES

ABA: P.T.H.

ABS: The paper takes a brief look at the principal forerunners of modern tidal power electric plants from classical times to the present. Tide mills in England date from the 12th and 13th century, and some were still in operation in the 1940s. In the U.S., Slade's mill, built in 1734, provided up to 375 kW. Modern facilities include the French plant on the Rance River estuary, which takes advantages of tides of exceptional amplitude. The only other operating tidal power plant is the Soviet 400 kW experimental plant built on the Kislogubskaya. Promising sites for projects include the Valdez peninsula in Argentina, the Gulf of San Jorge, Santa Cruz Bay, sites in northwestern Australia, the coasts of Chile and southern Argentina, sites on the Arabian Sea, the Bay of Bengal, the Gulf of Kutch, and the Gulf of Cambay.

79A18112 ISSUE 5 PAGE 868 CATEGORY 44 78/00/00  
14 PAGES UNCLASSIFIED DOCUMENT

UTTL: The economics of Fundy tidal power

AUTH: A/CLARK, R. H. PAA: A/(Environment Canada, Inland Waters Directorate, Canada)

In: International Symposium on Wave and Tidal Energy, Canterbury, England, September 27-29, 1978.

Proceedings, Volume 1. (A79-18101 05-44) Cranfield,

Beds., England, British Hydromechanics Research

Association Fluid Engineering, 1978, p. E3-41 to E3-54.

MAJS: /\*COST ANALYSIS/\*ECONOMIC ANALYSIS/\*TIDE POWERED GENERATORS

MINS: / BAYS (TOPOGRAPHIC FEATURES)/ CANADA/ CLEAN ENERGY/ COST ESTIMATES/ ELECTRIC POWER PLANTS/ ENERGY TECHNOLOGY/ FEASIBILITY ANALYSIS/ OPERATIONS RESEARCH/ POWER EFFICIENCY/ SITES/ SOCIAL FACTORS/ STRUCTURAL BASINS

ABA: P.T.H.

ABS: The tidal range in Fundy coupled with favorable topography provides a potential for energy generation estimated to be in the billions of kilowatt-hours annually. Estimates of costs for plants of various capacities at different Fundy sites are provided.

79A18101 ISSUE 5 PAGE 867 CATEGORY 44 78/00/00  
231 PAGES UNCLASSIFIED DOCUMENT

UTTL: International Symposium on Wave and Tidal Energy, University of Kent, Canterbury, England, September 27-29, 1978. Proceedings, Volume 1

AUTH: A/STEPHENS, H. S.; B/STAPLETON, C. A. PAT: A/(ED.)

Symposium sponsored by the British Hydromechanics

Research Association Fluid Engineering Cranfield,

Beds., England, British Hydromechanics Research

Association Fluid Engineering, 1978, 231 p. (For

individual items see A79-18102 to A79-19117)

MAJS: /\*CONFERENCES/\*TIDEPOWER/\*WATERWAVE ENERGY CONVERSION

MINS: / BEACONS/ ELECTRIC POWER PLANTS/ ENERGY TECHNOLOGY/

MARINE TECHNOLOGY/ OCEAN THERMAL ENERGY CONVERSION/

TECHNOLOGY UTILIZATION/ TIDE POWERED GENERATORS/

WATERWAVE POWERED MACHINES

ABA: P.T.H.

ABS: Proposals for wave and tidal energy plants, economic analyses of plant operation and integration into existing power networks, and experimental results on pilot facilities are reported. Topics studied include a theory of wave power absorption by two independently oscillating bodies, an 18-m long buoy with pneumatic chambers and eleven generators producing 1.25 MW for 3-m wave height, wave power systems for desalination, optimum sites for tidal power development in the Bay of Fundy, design and construction of marine structures for wave/tidal ocean thermal energy, and integrating wave power into the electricity supply system.

79A29797 ISSUE 11 PAGE 2058 CATEGORY 44  
78/00/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Some recent developments in wind and ocean power systems

AUTH: A/YEN, J. T. PAA: A/(Grumman Aerospace Corp., Bethpage, N.Y.)

In: Canadian Communications and Power Conference,

Montreal, Canada, October 18-20, 1978, Proceedings,

(A79-29776 11-32) New York, Institute of Electrical

and Electronics Engineers, Inc., 1978, p. 373-377.

MAJS: /\*ENERGY TECHNOLOGY/\*OFFSHORE ENERGY SOURCES/\* WINDPOWER UTILIZATION

MINS: / OCEAN CURRENTS/ TECHNOLOGY ASSESSMENT/ TIDEPOWER/ VORTICES/ WIND VANES

ABA: G.R.

ABS: A description is presented of a tornado-type wind energy system and its extension. Immense amounts of wind energy will be collected by a stationary and omni-directional collector which is a slotted cylinder fitted with adjustable vanes at its periphery. Collected wind energy is guided by the vanes to form a vortex or a 'confined tornado' within the collector. The low-pressure core of the vortex is then used to greatly reduce the back pressure of a turbine which is located directly below the vortex core. The underside of the turbine is connected to the ambient atmosphere through a bottom inlet.

79A27390 ISSUE 10 PAGE 1835 CATEGORY 44  
78/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Energy from sea waves - System optimization by diffraction theory

AUTH: A/SEBASTIANI, G.; B/BERTA, M.; C/BLANDINO, A. PAA: C/(Tecnomare S.p.A., Venice, Italy)

In: Oceans '78: The ocean challenge: Proceedings of the Fourth Annual Combined Conference, Washington, D.C., September 6-8, 1978. (A79-27376 10-48) Washington, D.C., Marine Technology Society; New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 590-595.

MAJS: /\*ENERGY CONVERSION EFFICIENCY/\*OFFSHORE ENERGY SOURCES/\*WATERWAVE ENERGY CONVERSION/\*WAVE DIFFRACTION

MINS: / CLEAN ENERGY/ COMPUTER TECHNIQUES/ CYLINDERS/ ENERGY TECHNOLOGY/ OPTIMIZATION

ABA: (Author)

ABS: The paper deals with a computerized method for the determination of the optimal conditions for an efficient extraction of energy from sea waves. The analyzed system is a floating cylinder connected to an energy extracting device. The system has been studied parametrically, by calculating its maximum efficiency in function of the geometric dimensions and layout configuration. The diffraction theory has been used in order to calculate the hydrodynamic terms (forces, added masses, damping coefficients) taking into account the real interaction between the body and the sea. Moreover a true statistic of waves is used in order to compare the efficiency of various systems in real sea conditions. The results obtained have confirmed the possibility of optimizing the system efficiency with respect to the parameters examined.

#### WIND, WAVES AND TIDES.

Engineering, vol. 218, no. 12, December 1978, p.1318-1321.

Two symposia were organised by BHRA Fluid Engineering during August and September 1978. The first dealt with wave and tidal energy, the second with wind-energy systems. This article summarises some of the work reported at the symposia

79A18115 ISSUE 5 PAGE 868 CATEGORY 44 78/00/00  
10 PAGES UNCLASSIFIED DOCUMENT

UTTL: Studies in retiming tidal energy

AUTH: A/GIBSON, R. A.; B/WILSON, E. M. PAA:

A/(Engineering and Power Development Consultants, Ltd., England); B/(Salford, University, Salford, Lancs., England)

In: International Symposium on Wave and Tidal Energy, Canterbury, England, September 27-29, 1978.

Proceedings, Volume 1. (A79-18101 05-44) Cranfield, Beds., England, British Hydromechanics Research

Association Fluid Engineering, 1978, p. H1-1 to H1-10.

MAJS: /\*ENERGY STORAGE/\*HYDROELECTRIC POWER STATIONS/\*TIDE POWERED GENERATORS

MINS: / ENERGY TECHNOLOGY/ HYDRAULIC EQUIPMENT/ PUMPS

ABA: P.T.H.

ABS: A study was conducted to determine how the benefits from an ebb-flow tidal power scheme were affected by retiming the off-peak tidal energy and how the effects varied with the scale of the installation. A plant on the Cumberland Basin in the Bay of Fundy linked to a pumped-storage facility at Dickey-Lincoln School Lakes was considered. Additional monetary benefit due to retiming is fundamentally dependent on the character of the electrical system and the pumping capacity available.

MATHEMATICAL MODEL FOR ECONOMIC EVALUATION OF TIDAL POWER IN THE BAY OF FUNDY, by Stephen T.Y. Lee and Claude Dechamps.

IEEE Transactions on Power Apparatus and Systems, vol. PAS-97, no. 5, Sept/Oct 1978, p. 1769-1778.

The mathematical models for the economic evaluation of tidal power development involving a primary and secondary markets are presented in the context of utilities' generation expansion planning. The approach is to determine the economic benefits of tidal power by the difference in the least-cost expansion plans with and without tidal development. The least-cost expansion plans are derived by a series of snapshot year simulation and generation mix optimization. The impact of storage devices and transmission between market areas are properly studied. These models have been successfully applied to the study of tidal power in the Bay of Fundy.



79A34084 ISSUE 13 PAGE 2420 CATEGORY 44  
78/00/00 31 PAGES UNCLASSIFIED DOCUMENT

UTTL: Energy from sea and air by large-span tensioned foils  
AUTH: A/BAILEY, D. Z. PAA: A/(Bailey Engineering, East

Greenwich, R.I.)  
In: Alternative energy sources: proceedings of the  
Miami International Conference, Miami Beach, Fla.,  
December 5-7, 1977. Volume 6. (A79-34067 13-44)  
Washington, D.C.: Hemisphere Publishing Corp., 1978.  
p. 2877-2907.

MAJS: /\*AIRFOILS/\*ENERGY SOURCES/\*HYDROFOILS/\*TIDEPOWER/\*  
WATERWAVE ENERGY CONVERSION/\*WINDPOWER UTILIZATION  
MINS: / AERODYNAMIC COEFFICIENTS/ ENERGY TECHNOLOGY/ GRAPHS  
(CHARTS)/ NUMERICAL ANALYSIS

ABA: (Author)

ABS: Kinetic energy in ocean and tidal streams, and in  
atmospheric winds may be extracted in large quantities  
by stretching hydro (aero) foils horizontally over  
large distances across moving streams. These foils can  
be made to span very large distances by designing them  
to sustain large tensile loads and arranging them in  
'catenary like' arcs such that the major forces are  
devoted of bending moments. Tensile loads are applied  
to the stream by placing massive concrete anchorages  
at opposing points across the stream. Thus the earth  
absorbs the complex compression forces presented by  
the energy flux. Supplementary structures stabilize  
the catenaries and extract the mechanical energy. For  
smaller systems of one to 10 Mw the axial thrust might  
be absorbed by one or more barges. George's Banks is a  
likely site for wind systems in the Northeast. Wind  
velocities and real estate values favor such a marine  
location where the array may stretch for miles.

#### 14165 INFORMATION REQUIREMENTS FOR IMPROVING HYDROPOWER

KEY WORDS: Decision making; Flood control; Hydroelectric power  
generation; Information systems; Remote sensing; Reservoirs; Streamflow  
forecasting; Watersheds

ABSTRACT: A method of analysis is described with the objective of determining how  
(and whether) aerospace derived information system technology can effectively increase  
hydropower production. The increase in annual hydropower benefits is derived from more  
accurate reservoir inflow forecasting based upon the use of new or improved sensors and  
satellite data relay systems. Sensitivity analyses are presented for watershed parameters  
imbedded in conceptual watershed models. Results are related to hydropower production  
and sensor requirements via a reservoir optimization model to establish information  
system requirements. A numerical example is presented using a typical multiple purpose  
reservoir system located in northern California.

REFERENCE: Yeh, William W-G., Becker, Leonard, and Sohn, Robert L., "Information  
Requirements for Improving Hydropower," *Journal of the Water Resources Planning and  
Management Division, ASCE*, Vol. 104, No. WR1, Proc. Paper 14165, November, 1978,  
pp. 139-156

#### POWER FROM GLACIERS: THE HYDROPOWER POTENTIAL OF GREENLAND'S GLACIAL WATERS, by R. Partl Energy, vol. 3, no. 5, October 1978, p. 543-573

Abstract—In the southern parts of Greenland, large quantities of water melting every summer from the ice  
shield 1000 m above sea level and more, within a short distance from the coast, offer favorable conditions  
for a large-scale hydropower development. General ideas on such a development have been published by  
several authors. This report tries to go a step further by providing an assessment of available resources, an  
analysis of technical problems for the utilization of this resource and its integration into a global energy  
system, and a preliminary estimate of construction needs and costs.

The estimate of available resources is based on published climatological data for Greenland and other  
arctic stations, and on a cautious selection of effective solar radiation and albedo values. 210-360 km<sup>3</sup> of  
water is expected to be available during the summer months at an average altitude of 1000 m, corresponding  
to an energy generation of 460-800 TWh. Continuous generation all-year-round, however, requires storage  
reservoirs with a total volume of 100-180 km<sup>3</sup>. In southwest Greenland, numerous large lakes will provide  
sufficient storage volumes. In the east, storage is a problem, and power generation might be restricted to the  
summer months.

Some 12 to 15 sites have been identified on the maps where power schemes can be developed with a  
total installed capacity of 60-120 GW; hence, the estimated hydropower resources of Greenland come close  
to the 1974 total consumption of electric energy in the interconnected grid system of Western Europe  
which, according to the statistics of UCPIE, was 724 TWh with a peak load of 118 GW.

Technologies for hydropower development are well established and already in progress towards the  
order of magnitude needed for Greenland; however, methods of collecting water melting from large ice  
surfaces have still to be studied and tested. The problem of bulk energy transport over great distances is  
common to all future global energy supply options, and not unique to Greenland energy. Carriers envisaged  
in the report are EHV sea cables and transmission lines on land, hydrogen gas pipelines across sea and land,  
and tankers for liquid hydrogen or ammonia. Preliminary cost comparisons show each of these carriers to  
be competitive under specific production and market conditions. The report gives a tentative model for the  
full development of Greenland's glacier power comprising all these options.

Construction cost of the power schemes is estimated at 275-320 US dollars per installed kilowatt, but  
another 220-430 US\$/kW have to be invested in transport facilities such as EHV links or H<sub>2</sub> gas pipelines.  
The use of liquid H<sub>2</sub> as an energy carrier requires lower investments but involves higher energy losses.

The integration of Greenland's glacier power into a global energy system is analyzed according to the  
criteria adopted for IASA's Energy Program. No need of fundamental innovation and no serious  
constraints have been identified for a full development, scheme by scheme, over a projected construction  
period of e.g. 40 years, starting after an initial testing, planning, and design period of e.g. 10 years. A  
tentative study program is suggested comprising the collection of basic scientific data, as well as  
preparatory technical investigations and tests to ascertain the technical feasibility of the development.

#### POWER FROM YESTERDAY'S DAMS, by Bruce Palmer Smith. Environment, vol. 20, no. 9, November 1978, p. 17-20.

Dams built 150 years ago to drive the machinery of New England's textile mills are  
currently being reexamined as a practical and relatively inexpensive way to supple-  
ment the area's energy resources.

RISK IN HYDROELECTRICITY PRODUCTION, by Herbert Inhaber.

Energy, vol. 3, no. 6, December 1978, p. 769-778.

**Abstract**—As in any energy system hydroelectricity can have risks to workers and to the public. When "risk accounting", or the summing of the risk to human health from the entire energy cycle, is used, hydroelectricity has fairly substantial values. It ranks fourth lowest in a selected group of 11 energy technologies, which are ordered as follows: natural gas, nuclear, ocean thermal, hydroelectricity, solar space heating, solar thermal electric, solar photovoltaic, wind, methanol, oil and coal. About half the risk in hydroelectricity generation is due to material acquisition and construction.

TJ 163.2 1977.  
.G74 Greater Los Angeles Area Energy Symposium  
1977 ... cl977.  
ix, 179 p. : ill. — (Los Angeles Council of Engineers Scientists proceedings series ; v. 3)  
Cover title:  $Q = E^3$  : Quality of life = energy x economics x environment.

Tidal Power Update '77

Edward F. Wehlage, P.E., Consulting Engineer

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## HYDROELECTRIC PLANT CAPABILITY CURVES.

W. T. Alley

IEEE Transactions on Power Apparatus and Systems,  
vol. PAS-96, no. 3, May/June 1977, p. 999 - 1003

## PROCESS CONTROL SYSTEMS IN HYDRO-ELECTRIC POWER STATIONS

H. Cvetko, Baden

Brown Boveri Review

Vol. 64, 1977,

pp. 297-304.

*In the introduction the article briefly goes into the demands arising from the power station process and its management. It deals primarily with the field of control, and explains how the reliability and availability of hydro-electric power stations can be increased. Two examples of practical application and a consideration of future prospects conclude the article.*

77A47749 ISSUE 22 PAGE 3818 CATEGORY 45  
77/08/00 11 PAGES UNCLASSIFIED DOCUMENT

UTTL: Predicting the rate of warming of rivers below hydroelectric installations

AUTH: A/TROXLER, R. W.; B/THACKSTON, E. L. PAA:  
A/(Georgia, Dept. of Natural Resources, Atlanta, Ga.);  
B/(Vanderbilt University, Nashville, Tenn.)  
Water Pollution Control Federation, Journal, vol. 49,  
Aug. 1977, p. 1902-1912.

MAJS: /\*ENERGY BUDGETS/\*HYDROELECTRIC POWER STATIONS/\*RIVERS  
/\*THERMAL POLLUTION/\*WATER TEMPERATURE

MINS: / ATMOSPHERIC RADIATION/ HEAT TRANSFER/ SOLAR  
RADIATION/ TEMPERATURE PROFILES

ABA: S.C.S.

ABS: The construction and verification of an energy budget model is described for the accurate prediction of temperature changes in flowing rivers based on the approximate geometry of the rivers, and data from first order weather stations. The results of five field surveys to test the model show that (1) atmospheric radiation and back radiation almost balance each other, (2) evaporation and conduction energy transfers are of minor importance, and (3) solar radiation accounted for almost all of the energy transfer. When the river was above the equilibrium temperature it was shown that (1) back radiation would be greater, (2) evaporation and conductive heat transfer would be negative, and (3) the total energy transfer would be negative.

Alternative Sources of Energy, no.28, Oct.1977.

#### Special Hydro Power Section

- A Do-It-Yourself, Axial-flow, Low-head Turbine by Felix Meinikheim. . . .4  
Handmade Hydro Power by Harry Langhorne. . . . .7  
A Working Pelton Wheel by Felix Meinikheim. . . . .12  
Free Heat Turns Wonder Wheel by H.L. Miller . . . . .16

TJ 163.9 Energy technology handbook : prepared by 142  
specialists / Douglas M. Considine, editor-  
.E54 in-chief. -- New York : McGraw-Hill, c1977.  
1874 p. in various pagings : ill. ; 24 cm.  
Includes index.  
ISBN 0-07-012430-2

#### HYDROPOWER TECHNOLOGY

- Hydropower . . . . . 8-3  
Tidal Energy . . . . . 8-25

#### 13193 ENVIRONMENTAL IMPACT OF HYDRO POWER PLANTS

KEY WORDS: Benthic fauna; Environmental impact statements; Fish;  
Hydroelectric powerplants; Hydroelectric project licensing; Invertebrates;  
Water quality

ABSTRACT: Hydroelectric power plants sited on rivers and streams change the natural conditions of these water bodies through both short-term and long-term impacts. Therefore, changes in water quality, erosion, fluctuation in water temperature and water flow, and eutrophication must be studied in planning future hydroelectric installations. The objectives of this paper are to describe briefly the reported physical, chemical, and hydrodynamic changes associated with hydroelectric dams and to relate some of these changes to the fish and benthic communities of the lower Susquehanna River. Several aspects of the impacts of hydroelectric projects are briefly considered and changes in the lower Susquehanna River, the site of four large dams, are evaluated in light of disruption of the upstream runs of the previously existing migratory fishes. Changes in the structure of the benthic community are also analyzed based on literature reviewed.

REFERENCE: El-Shamy, Farouk M., "Environmental Impacts of Hydroelectric Power Plants," *Journal of the Hydraulics Division, ASCE*, Vol. 103, No. HY9, Proc. Paper 13193, September, 1977, pp. 1007-1020

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Offshore and underground power plants.  
Robert Noyes, Ed.  
Noyes Data Corp. 1977.

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78A53248 ISSUE 24 PAGE 4385 CATEGORY 44  
78/10/00 8 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Raw tidal energy absorption capability of a power system  
AUTH: A/FURST, G. B.; B/SUD, S. PAA: B/(Tidal Power Consultants, Ltd., Montreal, Canada)  
(Institute of Electrical and Electronics Engineers, Summer Meeting, Mexico City, Mexico, July 17-22, 1977.) IEEE Transactions on Power Apparatus and Systems, vol. PAS-97, Sept.-Oct. 1978, p. 1910-1915; Discussion, p. 1916, 1917.  
MAJS: /ELECTRIC POWER PLANTS/\*ENERGY ABSORPTION/\*HYDROELECTRIC POWER STATIONS/\*TIDEPower/\*WATERWAVE ENERGY CONVERSION  
MINS: / ENERGY CONSERVATION/ ENERGY TECHNOLOGY/ TIME LAG  
ABA: (Author)  
ABS: This paper presents a new and efficient semiprobabilistic method developed during the Bay of Fundy studies, to determine the raw tidal energy absorption capability of a power system. This method uses the annual load and tidal duration shapes, but does not require the hourly simulation of system load and tidal generation. The power system constraints on raw tidal energy absorption and the concept of 'must-run' generation together with the modification of the annual load duration curve are also discussed.



A77-47971 # Progress of feasibility reassessment of exploiting Fundy tidal energy. R. H. Clark and R. L. Walker. *Engineering Institute of Canada, Annual Congress, 90th, Halifax, Nova Scotia, Canada, Oct. 5-8, 1976, Paper. 43 p. 9 refs.*

A joint Canadian and provincial government program to assess the technical, environmental and economic feasibility of electrical power generation from tidal energy at the Bay of Fundy (Nova Scotia-New Brunswick) is reviewed. Aspects of the design process, including the choice between single and hydraulically-linked basin schemes, the integration of power plants into existing transmission systems, the development of a finite difference model for more accurate simulation of tidal flow, the estimation of capital costs for plants having capacities from 50 to 10,000 MW and the location and capacity of energy storage facilities, are considered. In addition, utility loads in the Canadian maritime provinces and Quebec through the 1990's are projected, and the relative cost of tidal energy from the proposed Bay of Fundy generating plants is estimated. J.M.B.

TJ Energy development II ... cl976. (Card 2)  
153 covering papers presented at the National  
.E4733 Power Engineering Society meetings."  
pt.2 1. Power resources—Congresses. 2.  
Electric power—Congresses. I. IFEF  
Power Engineering Society. IEFEE Power  
Generation Committee. Energy Development  
Subcommittee. II. Series.

Operating Experience with Bulb Units at the Rance Tidal Power Plant  
and Other French Hydro-Power Sites, by H. André.....

79A18111 ISSUE 5 PAGE 868 CATEGORY 44 78/00/00  
18 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Review of optimization and economic evaluation of  
potential tidal power developments in the Bay of Fundy  
AUTH: A/FURST, G. B.; B/SWALES, M. C. PAA: B/(Tidal Power  
Consultants, Ltd., Montreal, Canada)  
In: International Symposium on Wave and Tidal Energy.  
Canterbury, England, September 27-29, 1978.  
Proceedings, Volume 1. (A79-18101 05-44) Cranfield,  
Beds., England, British Hydromechanics Research  
Association Fluid Engineering, 1978, p. E2-23 to  
E2-40.  
MAJS: /\*ECONOMIC ANALYSIS/\*OPTIMIZATION/\*SITES/\*TIDEPOWER  
MINS: / BAYS (TOPOGRAPHIC FEATURES)/ CANADA/ ELECTRIC POWER  
PLANTS/ ENERGY TECHNOLOGY/ SYSTEMS ENGINEERING/ TABLES  
(DATA)

79A18110 ISSUE 5 PAGE 868 CATEGORY 44 78/00/00  
22 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Selection of optimum sites for tidal power development  
in the Bay of Fundy  
AUTH: A/WARNOCK, J. G.; B/TANNER, R. G. PAA: B/(Acres  
Consulting Services, Ltd., Canada)  
In: International Symposium on Wave and Tidal Energy.  
Canterbury, England, September 27-29, 1978.  
Proceedings, Volume 1. (A79-18101 05-44) Cranfield,  
Beds., England, British Hydromechanics Research  
Association Fluid Engineering, 1978, p. E1-1 to E1-22.  
MAJS: /\*ELECTRIC POWER PLANTS/\*SITES/\*TIDE POWERED  
GENERATORS  
MINS: / BAYS (TOPOGRAPHIC FEATURES)/ CANADA/ CLEAN ENERGY/  
COST ESTIMATES/ ENERGY TECHNOLOGY/ OPTIMIZATION/  
STRUCTURAL BASINS/ STRUCTURAL DESIGN/ STRUCTURAL  
ENGINEERING/ TURBOGENERATORS

XI. MAGNETOHYDRODYNAMICS AND ELECTROHYDRODYNAMICS . . . . .	1027
A. Magnetohydrodynamic Generators . . . . .	1028
B. Electrohydrodynamic Generators . . . . .	1055



## MAGNETOHYDRODYNAMIC GENERATORS

TK  
2896  
.I55  
1979

Intersociety Energy Conversion Engineering Conference, 14th, Boston, 1979.  
Proceedings of the 14th Intersociety Energy Conversion Engineering Conference, Boston, Massachusetts, August 5-10, 1979.  
-- Washington, D. C. : American Chemical Society, c1979.

2 v. (xviii, 2078, 294 p.) : ill.  
"IEEE 79CH1477-9 Energy."

Includes bibliographical references and index.

### Magnetohydrodynamics (MHD)

799411  
Open-Cycle Coal-Fired Liquid-Metal MHD.  
E.S. Pierson, M. Petrick, F. Schreiner, D. Cohen and R.S. Smith ..... 1912

799412  
Considerations for Adapting an MHD Baseload Power Plant for Intermediate and Peaking Duty, W.R. Owens and J.J. Lynch ... 1918

799413  
Environmental Assessment of Coal-Fired Open Cycle MHD Power Plant, C.D. Kafadelis, H. Shaw, D.W. Blair, B.A. Folsom and T.A. Corley ..... 1923

799415  
Operability and Materials Testing for MHD Air Heaters, D.P. Saari, R.R. Smyth, C.J. Kniebel and L.R. White ..... 1931

799416  
Performance Optimization of an MHD Generator with Physical Constraints, C.C.P. Pian, G.R. Seikel and J.M. Smith ..... 1939

79A19587# ISSUE 6 PAGE 1026 CATEGORY 44 RPT#:  
AIAA PAPER 79-0188 79/01/00 12 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: National program for the development of commercial MHD  
AUTH: A/SHANKLIN, R. V. PAA: A/(U.S. Department of Energy, Washington, D.C.)  
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979. 12 p.

MAJS: /\*COAL UTILIZATION/\*COMMERCIAL ENERGY/\*ELECTRIC POWER PLANTS/\*ENERGY POLICY/\*MAGNETOHYDRODYNAMIC GENERATORS  
MINS: / BOILERS/ ECONOMIC FACTORS/ ELECTRICAL ENGINEERING/ ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY/ PRODUCT DEVELOPMENT/ TURBOGENERATORS

FREQUENCY/ DISTRIBUTION FUNCTIONS/ ELECTRON DENSITY (CONCENTRATION)/ MAGNETOHYDRODYNAMIC FLOW/ SAHA EQUATIONS/ TEMPERATURE GRADIENTS

ABA: (Author)

ABS: An investigation of the effect of velocity/temperature boundary layers on the conductivity and the power output of an MHD generator has been presented in this paper: the analysis is based on the Boltzmann transfer equation. It is seen that the conductivity and the mean power output per unit volume of an MHD generator becomes considerably reduced because of the presence of the velocity and temperature boundary layers. The power output is found to decrease sharply with boundary-layer thickness for low values of the thickness and levels off at larger thicknesses.

A80-25097 # Conceptual design of an MHD/steam power plant of pilot scale /ETF/ and preliminary analyses of early commercial MHD power plants. F. Becker, F. Hals, R. Kessler, L. Westra (Avco Everett Research Laboratory, Inc., Everett, Mass.), W. Morgan (Chas T. Main, Inc., Boston, Mass.), and C. Bozzuto (Combustion Engineering, Inc., Windsor, Conn.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 18th, Butte, Mont., June 18-20, 1979, Preprints. (A80-25061 09-31) Bozeman, Mont., Montana State University, 1979, p. G.3.1-G.3.20. 6 refs. Research supported by the U.S. Department of Energy.

79A33385# ISSUE 13 PAGE 2410 CATEGORY 44 CNT#:  
EF-77-C-01-2613 78/00/00 8 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Cyclone and fluidized bed combustion concepts for coal fired open cycle MHD

AUTH: A/OMORI, S.; B/HNAT, J.; C/BAZAN, J.; D/BISWAS, B.  
PAA: B/(General Electric Co., Space Div.,  
Philadelphia, Pa.); D/(Foster-Wheeler Development  
Corp., John Blizard Research Center, Livingston, N.J.)  
In: Symposium on the Engineering Aspects of  
Magnetohydrodynamics, 17th, Stanford, Calif., March  
27-29, 1978, Proceedings. (A79-33379 13-31) Stanford,  
Calif., Stanford University, 1978, p. A.6.1-A.6.8.

MAJS: /\*COAL GASIFICATION/\*COMBUSTION CHAMBERS/\*FLUIDIZED  
BED PROCESSORS/\*FUEL COMBUSTION/\*MAGNETOHYDRODYNAMIC  
GENERATORS/\*PERFORMANCE PREDICTION

MINS: / ASHES/ BEDS (PROCESS ENGINEERING)/ FIRING (IGNITING)  
/ RELIABILITY ANALYSIS/ SLAGS/ SYSTEMS ENGINEERING/  
THERMODYNAMIC CYCLES/ VAPOR PHASES

ABA: (Author)

ABS: Predicted performances of fluidized bed and cyclone  
combustion schemes were compared as part of a recent  
conceptual design study of a sub-scale (250 Mw),  
open-cycle MHD Engineering Test Facility (ETF). Both  
combustion concepts were two-stage  
gasification/combustion systems designed for high  
slag/ash rejection with predictions for slag/ash  
rejection being greater than 99% and 90% for the  
fluidized bed and cyclone concepts respectively. For  
the particular two-stage combustion systems evaluated,  
analyses indicated that for the same thermal input,  
maximum air preheat temperature, and exit pressure,  
the cyclone combustion scheme had slightly better  
thermodynamic performance than the fluidized bed  
scheme. When integrated into combined cycle (MHD  
topping, steam bottoming) power plants, the overall  
plant efficiencies utilizing each of these combustion  
concepts differed by about 2 percentage points with  
the cyclone concept yielding the higher plant  
efficiencies. Aside from thermodynamic performance,  
considerations of subsystem interactions, practical  
plant operation, reliability and system design  
flexibility favor the fluidized bed concept over the  
cyclone design for the intended purpose of the ETF.

79A52968 ISSUE 24 PAGE 4555 CATEGORY 45 CNT#:  
EP-78-C-02-465\* EF-77-C-01-2430 79/10/00 6 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: MHD emissions and their controls

AUTH: A/MATRAY, P.; B/HUDDLESTON, G. PAA: B/(Montana  
Energy and MHD Research and Development Institute,  
Inc., Butte, Mont.)  
Environmental Science and Technology, vol. 13, Oct.  
1979, p. 1208-1213.

MAJS: /\*COAL UTILIZATION/\*COMBUSTION PRODUCTS/\*ELECTRIC  
POWER PLANTS/\*ENVIRONMENT POLLUTION/\*

MINS: / EFFLUENTS/ ENERGY TECHNOLOGY/ ENVIRONMENTAL  
MONITORING/ NITROGEN OXIDES/ SOLID WASTES/ SULFUR  
DIOXIDES/ TRACE ELEMENTS

ABA: C.F.W.

ABS: The use of magnetohydrodynamics (MHD) as a new energy  
technology due to its efficiency and  
cost-effectiveness is examined. Three major goals of  
the DOE are discussed, which include (1) achieving  
overall coal-to-busbar efficiencies near 50% in MHD  
demonstration facilities, (2) demonstrating the  
economic feasibility of MHD, and (3) meeting  
environmental emission standards for sulfur dioxide,  
nitrogen oxides, and particulates. Attention is given  
to MHD generated wastes such as seed, fly ash, and  
slag, and those generated by conventional coal-fired  
power plants. The three major EPA regulations which  
affect air quality, such as NSPS, PSD, and the  
National Ambient Air Quality Standards (NAAQS) are  
discussed and their bearing on the development of MHD  
is noted.

79N21557# ISSUE 12 PAGE 1590 CATEGORY 44 RPT#:  
PNL-2004-B CNT#: EY-76-C-06-1830 78/08/00 44  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Development, characterization and evaluation of  
materials for open cycle MHD

AUTH: A/BATES, J. L.; B/MARCHANT, D. D.; C/DANIEL, J. L.  
CORP: Battelle Pacific Northwest Labs., Richland, Wash.  
AVAIL NTIS SAP: HC A03/MF A01

MAJS: /\*CERAMICS/\*ELECTRODES/\*INSULATORS/\*  
MAGNETOHYDRODYNAMIC GENERATORS

MINS: / CHEMICAL COMPOSITION/ DIRECT CURRENT/ ELECTRIC  
FIELDS/ ELECTRICAL RESISTIVITY/ ELECTROCHEMISTRY/  
INTERNATIONAL COOPERATION/ METAL OXIDE SEMICONDUCTORS/  
MICROSTRUCTURE/ MIS (SEMICONDUCTORS)/ THERMAL  
CONDUCTIVITY/ THERMAL DIFFUSION

ABA: J.M.S.

ABS: Progress in the development of high temperature  
ceramics for open cycle, coal-fired MHD power  
generators is reported. Emphasis is placed on  
electrode and insulator materials. Specific areas  
covered include: (1) electrochemical effects of alkali  
seed/coal slags on electrodes and insulators; (2)  
characterization of material from Westinghouse MHD  
proof tests; (3) thermal diffusivity/conductivity; (4)  
electrical conductivity of oxide insulators; and (5)  
materials development.

79A10142 ISSUE 1 PAGE 63 CATEGORY 33 CNT\*:  
EX-76-C-01-1760 78/00/00 6 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Design studies and trade-off analyses for a  
superconducting magnet/MHD power generator system  
AUTH: A/CHAPMAN, J. N.; B/MARTIN, J. F.; C/MUEHLHAUSER, J.  
W.; D/PETERSEN, C. K.; E/WU, Y. C. L.; F/DICKS, J.  
B. PAA: F/(Tennessee, University, Tullahoma, Tenn.)  
In: Intersociety Energy Conversion Engineering  
Conference, 13th, San Diego, Calif., August 20-25,  
1978, Proceedings, Volume 2. (A79-10001 01-44)  
Warrendale, Pa., Society of Automotive Engineers,  
Inc., 1978, p. 1283-1288.  
MAJS: /\*COAL UTILIZATION/\*DESIGN ANALYSIS/\*  
MAGNETOHYDRODYNAMIC GENERATORS/\*SUPERCONDUCTING  
MAGNETS/\*SYSTEMS ENGINEERING  
MINS: / COMBUSTION CHAMBERS/ ELECTRIC POWER PLANTS/ ENERGY  
TECHNOLOGY/ TRADEOFFS  
ABA: G. R.  
ABS: The considered system is to be used in a facility  
which is designed for the development of coal fired  
MHD systems. The facility, as presently planned, will  
provide a mixture of oxygen and nitrogen preheated by  
a heater to simulate oxygen enriched air. Four  
principal equations bearing on the selection of a  
physical configuration for the magnet are  
investigated. An analysis indicates that a  
superconducting magnet having an overall length of 5  
M. (3.1 M. effective length) with a warm bore having  
an entrance diameter of .6M or larger and capable of  
supporting the channel loading, a peak magnetic field  
of 6 Tesla and a warm bore taper that matches MHD  
Generator taper for the 27.8 Kg/sec mass flow case  
provides the best choice for experimental utility in  
the facility.

79A33379 ISSUE 13 PAGE 2352 CATEGORY 31  
78/00/00 361 PAGES UNCLASSIFIED DOCUMENT

UTTL: Symposium on the Engineering Aspects of  
Magnetohydrodynamics, 17th, Stanford University,  
Stanford, Calif., March 27-29, 1978, Proceedings  
AUTH: A/KRUGER, C. H. PAA: A/(Stanford University,  
Stanford, Calif.) PAT: A/(ED.) SAP: \$20  
Symposium sponsored by Stanford University Stanford,  
Calif., Stanford University, 1978 361 p (for  
individual items see A79-33380 to A79-33429)  
MAJS: /\*CONFERENCES/\*MAGNETOHYDRODYNAMIC GENERATORS/\*SYSTEMS  
ENGINEERING/\*THERMODYNAMIC CYCLES  
MINS: / CHANNEL FLOW/ CLOSED CYCLES/ COAL GASIFICATION/ COAL  
UTILIZATION/ ELECTRODYNAMICS/ ENERGY TECHNOLOGY/ FLUID  
DYNAMICS/ FUEL COMBUSTION/ MAGNETOHYDRODYNAMICS/  
PLASMA ELECTRODES/ PLASMA JETS/ SLAGS/ THERMODYNAMICS  
ABA: B. J.  
ABS: MHD power generation is discussed with reference to  
MHD coal combustion, open cycle processes, slag  
effects, and electrode wall materials. Consideration  
is also given to discharge and plasma effects, open  
cycle processes, and component design.

79A10137 ISSUE 1 PAGE 142 CATEGORY 75 78/00/00  
8 PAGES UNCLASSIFIED DOCUMENT

UTTL: A proposed 40 MWe MHD pilot plant  
AUTH: A/WAY, S.  
In: Intersociety Energy Conversion Engineering  
Conference, 13th, San Diego, Calif., August 20-25,  
1978, Proceedings, Volume 2. (A79-10001 01-44)  
Warrendale, Pa., Society of Automotive Engineers,  
Inc., 1978, p. 1249-1256.  
MAJS: /\*ELECTRIC POWER PLANTS/\*MAGNETOHYDRODYNAMIC  
GENERATORS/\*PILOT PLANTS/\*STEAM TURBINES/\*  
TURBOGENERATORS  
MINS: / CARBONATES/ COAL UTILIZATION/ COMBUSTION CHAMBERS/  
ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY/  
POTASSIUM  
ABA: (Author)  
ABS: The proposed plant would put out 40 MW of DC power  
from the MHD generator (39.2 MW of AC power), and  
have a thermal rating of 182.87 MW. Total net station  
electrical output, including the steam turbo  
generator, is about 76 MW. A two stage combustor is  
used with a slagging vortex gasifier first stage. The  
generator channel proposed is of hot wall design,  
slightly under 7 m. long, with 5.8 tesla field. Air  
preheat is 1360 K, to give a top temperature 2700 K. A  
radiant direct fired recuperator would be used. Fuel  
assumed is a Western Pennsylvania bituminous. Seeding  
is by 0.7% (weight) potassium, put in as dry  
carbonate. This plant might be upgraded to 50/90 MW  
for use as a transition MHD steam power installation.

79A34456 ISSUE 14 PAGE 2618 CATEGORY 44  
78/00/00 7 PAGES UNCLASSIFIED DOCUMENT

UTTL: Engineering studies of open-cycle coal-fired MHD for  
power generation  
AUTH: A/RETALLICK, F. D.; B/LIPPERT, T. E. PAA:  
B/(Westinghouse Electric Corp., Pittsburgh, Pa.)  
In: American Power Conference, Chicago, Ill., April  
24-26, 1978, Proceedings, Volume 40. (A79-34451 14-44)  
Chicago, Illinois Institute of Technology, 1978, p.  
457-463.  
MAJS: /\*COAL UTILIZATION/\*ELECTRIC POWER PLANTS/\*  
MAGNETOHYDRODYNAMIC GENERATORS/\*THERMODYNAMIC CYCLES  
MINS: / COMBUSTION CHAMBERS/ COMMERCIAL ENERGY/ ENERGY  
TECHNOLOGY  
ABA: J. M. B.  
ABS: Open-cycle coal-fired MHD-steam power plants offer a  
high fuel conversion efficiency and competitively  
priced electricity. Characteristics of MHD plants are  
discussed as a function of nominal thermal rating; the  
development of effective high-temperature air heaters  
is seen as a chief need for commercial MHD plants. A  
number of options for open-cycle MHD plants are  
reviewed; combustor temperature, combustor and channel  
designs, magnet parameters, sulfur removal techniques  
and seed recovery schemes.



78A24002# ISSUE 8 PAGE 1416 CATEGORY 44 RPT#:  
AIAA PAPER 78-291 CNT#1 DOE-76-C-01-1760 78/02/00  
7 PAGES UNCLASSIFIED DOCUMENT

UTTL: Electricity from coal by the MHD process  
AUTH: A/DICKS, J. B. PAA: A/(Tennessee, University,  
Tullahoma, Tenn.)  
American Institute of Aeronautics and Astronautics,  
Annual Meeting and Technical Display, 14th,  
Washington, D.C., Feb. 7-9, 1978, 7 p. U.S.  
Department of Energy  
MAJS: /COAL UTILIZATION/COMBUSTION EFFICIENCY/ENERGY  
TECHNOLOGY/MAGNETOHYDRODYNAMIC GENERATORS  
MINS: /COMBUSTION CHAMBERS/ELECTRIC POWER PLANTS/  
TECHNOLOGY UTILIZATION  
ABA: (Author)  
ABS: Central-station MHD power generation grew out of  
high-temperature gas-flow and combustion technology  
developed in rocket propulsion programs in the  
aerospace field during the 1950's. Rocket combustion  
technology modified to burn coal is coupled with  
fossil-fired boiler technology. Increased  
understanding of the applications of MHD power  
generation, and innovative concepts in sulfur and  
NO(x) control to make possible MHD power plants which  
can, in early stages, convert coal commercially into  
electrical energy at overall efficiencies of 48  
percent within the next 10 years. In later stages,  
efficiencies of 55 percent and above can be  
commercialized. A coal-fired MHD power system is  
described along with the next version of such a  
system, which will be capable of feeding coal at rates  
up to 10 tons per hour. The advances in this  
technology, future technology development required,  
and the cost effectiveness of this technical approach  
to power generation are discussed.

TK Magnetohydrodynamic energy for electric  
2970 power generation / edited by Robert F.  
.M326 Grumby. — Park Ridge, N.J. : Noyes Data  
Corp., 1978.  
x, 230 p. : ill. ; 25 cm. — (Energy  
technology review ; no. 20)

This book is limited to the potential of MHD in the production of the much-  
needed 60-Hz alternating current at less cost and less fuel consumption than by  
conventional power-generating systems. As such it presents an accurate status re-  
port based largely on federally funded studies.

Because the information in this book is taken from many sources, it is possible  
that certain portions of this book may disagree or conflict with other parts of the  
book. This is especially true of monetary values and opinions of future potential.

79A16462# ISSUE 4 PAGE 706 CATEGORY 75  
78/00/00 39 PAGES UNCLASSIFIED DOCUMENT

UTTL: Technical and economic aspects of open-cycle MHD power  
plants  
AUTH: A/PETRICK, M.; B/SHUMIATSKII, B. IA.; C/KORIAGINA,  
G. M. PAA: A/(Argonne National Laboratory, Argonne,  
Ill.); B/(Akademiya Nauk SSSR,  
Nauchno-Issledovatel'skii Institut Vysokikh  
Temperatur, Moscow, USSR)  
In: Open-cycle magnetohydrodynamic electrical power  
generation. (A79-16478 G4-75) Argonne, Ill., Argonne  
National Laboratory; Moscow, Izdatel'stvo Nauka, 1978,  
p. 88-126.  
MAJS: /ECONOMIC FACTORS/ELECTRIC POWER PLANTS/  
MAGNETOHYDRODYNAMIC GENERATORS/POWER EFFICIENCY/  
THERMODYNAMIC CYCLES  
MINS: /COMBUSTION PRODUCTS/COST EFFECTIVENESS/ENERGY  
CONVERSION EFFICIENCY/GAS HEATING/HEATING EQUIPMENT/  
WORKING FLUIDS  
ABA: S.D.  
ABS: The technical-economic system studies of open-cycle  
MHD power plants have identified the technological,  
operational, and cost parameters necessary for central  
station application. Among them are required hours of  
operation; air preheat temperature; oxygen enrichment  
of oxidizer; ionizing seed concentration; injection,  
recovery, and regeneration; magnetic field; electrical  
load coefficient; working fluid velocity in the MHD  
generator; initial pressure of combustion products;  
cycle and system configuration; and cost and type of  
fuel utilized. The required performance levels and the  
sensitivity of overall system performance to  
variations of these parameters are delineated. MHD  
power systems for intermediate- and peak-load  
applications as well as comparative cost studies are  
examined. The results of the system studies are  
summarized in a table which lists the performance  
values of critical plant parameters that will have to  
be achieved for both the near-term and the advanced  
plants.

79A16478 ISSUE 4 PAGE 705 CATEGORY 75 78/00/00  
727 PAGES UNCLASSIFIED DOCUMENT

UTTL: Open-cycle magnetohydrodynamic electrical power generation --- Book

AUTH: A/PETRICK, M.; B/SHUMIATSKII, B. IA. PAA:  
A/(Argonne National Laboratory, Argonne, Ill.);  
B/(Akademiia Nauk SSSR, Nauchno-Issledovatel'skii  
Institut Vysokikh Temperatur, Moscow, USSR) PAT:  
A/(ED.)  
Argonne, Ill., Argonne National Laboratory; Moscow,  
Izdatel'stvo Nauka, 1978, 727 p. (For individual items  
see A79-16479 to A79-16492)

MAJS: /\*ELECTRIC POWER PLANTS/\*ENERGY TECHNOLOGY/\*  
MAGNETOHYDRODYNAMIC GENERATORS/\*THERMODYNAMIC CYCLES

MINS: / ENVIRONMENT PROTECTION/ FUEL COMBUSTION/ HIGH  
TEMPERATURE RESEARCH/ INOCULATION/ PLASMA DIAGNOSTICS/  
SUPERCONDUCTING MAGNETS/ TURBOGENERATORS

ABA: S.D.

ABS: The present U.S./U.S.S.R. joint report on open-cycle  
MHD electrical power generation first examines general  
problems of MHD power plants, including discussion of  
general plant characteristics, selection of optimal  
configurations and plant layouts, evaluation of  
technical and economic aspects of open-cycle MHD power  
plants along with an outlook for their future  
application in power generation, and protection of the  
biosphere. Then the electrical equipment of an MHD  
installation is discussed relative to MHD generator  
and superconducting magnet system and the dc  
conversion (inverter) system. The high-temperature  
oxidizer preheater, the fuel processing and combustion  
system, steam generator, turbines, compressors, and  
the ionizing seed system are assessed. Also discussed  
are relevant problems of high-temperature materials  
for MHD energy conversion as well as plasma  
diagnostics in an MHD installation.

79A17638# ISSUE 5 PAGE 898 CATEGORY 75  
78/00/00 22 PAGES UNCLASSIFIED DOCUMENT

UTTL: MHD power generation

AUTH: A/HALS, F. A.; B/STICKLER, D. B.; C/KESSLER, R.;  
D/GANNON, R. E. PAA: D/(Avco Everett Research  
Laboratory, Inc., Everett, Mass.)  
In: Coal technology '78: International Coal  
Utilization Convention, Houston, Tex., October 17-19,  
1978, Conference Papers, Volume 1 (A79-17631 05-44)  
Houston, Tex., Industrial Presentations, 1978, p.  
423-444.

ORIGINAL PAGE IS  
OF POOR QUALITY

ABA: G.R.

ABS: In a magnetohydrodynamic (MHD) generator an  
electrically conducting gas replaces the rotating  
copper coil of the currently used electric generator.  
This substitution involves a principle which was  
recognized 150 years ago by Faraday. Development of  
the MHD process as an industrial method of generating  
electricity, however, had to wait until a better  
understanding of the dynamics and handling of hot  
gases in the range of 4000 to 5000 F was developed.  
Much of the necessary experience in dealing with such  
hot gases was gained in the aerospace industry in  
solving the ballistic missile reentry problem. The  
dominant position of coal in the future energy supply  
projections and the high temperatures attained in  
open-cycle operation make coal burning open-cycle  
designs the most promising for future energy  
conversion systems. Aspects of technology development  
are discussed, giving attention to the MHD channel,  
the superconducting magnet, the coal combustor, a high  
temperature air preheater, and approaches for seed  
recovery.

79A16479# ISSUE 4 PAGE 654 CATEGORY 44  
78/00/00 15 PAGES UNCLASSIFIED DOCUMENT

UTTL: The MHD power plant and its environmental aspects -  
Introduction

AUTH: A/PETRICK, M.; B/SHUMIATSKII, B. IA. PAA:  
A/(Argonne National Laboratory, Argonne, Ill.);  
B/(Akademiia Nauk SSSR, Nauchno-Issledovatel'skii  
Institut Vysokikh Temperatur, Moscow, USSR)  
In: Open-cycle magnetohydrodynamic electrical power  
generation. (A79-16478 04-75) Argonne, Ill., Argonne  
National Laboratory; Moscow, Izdatel'stvo Nauka, 1978,  
p. 1-15.

MAJS: /\*ELECTRIC POWER PLANTS/\*ENERGY CONVERSION EFFICIENCY  
/\*ENVIRONMENT EFFECTS/\*MAGNETOHYDRODYNAMIC GENERATORS

MINS: / ECONOMIC FACTORS/ ENERGY TECHNOLOGY/ FOSSIL FUELS/  
LIQUID METALS/ PLASMA PHYSICS

ABA: S.D.

ABS: The concept of MHD energy conversion becomes a viable  
possibility only with the proper combination of fluid  
velocity, electrical conductivity, and magnetic field  
strength. The search for that proper combination has  
led to the development of three distinct approaches to  
MHD power generation, viz. the open-cycle plasma,  
closed-cycle plasma, and liquid metal MHD concepts.  
This paper is concerned solely with the status of  
development of open-cycle MHD and is essentially based  
on the work carried out in the United States and the  
Soviet Union. Attention is given to factors motivating  
the development of open-cycle MHD, energy situation in  
the United States and the Soviet Union. Also discussed  
are recent advances in MHD and programs for the  
development of open-cycle MHD in both countries.



79A16614# ISSUE 4 PAGE 558 CATEGORY 20 CNT#:  
NGL-49-002-044 78/00/00 15 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: MHD conversion of solar energy --- space electric power system

AUTH: A/LAU, C. V.; B/DECHER, R. PAA: B/(Washington University, Seattle, Wash.)

CORP: Washington Univ., Seattle.  
In: Radiation energy conversion in space; Conference, 3rd, Moffett Field, Calif., January 26-28, 1978. Technical Papers. (A79-16601 04-44) New York, American Institute of Aeronautics and Astronautics, Inc., 1978. p. 186-200.

MAJS: /\*ENERGY CONVERSION EFFICIENCY/\*MAGNETOHYDRODYNAMIC GENERATORS/\*SATELLITE SOLAR POWER STATIONS/\*SOLAR ENERGY ABSORBERS/\*SOLAR GENERATORS

MINS: / ELECTRIC POWER PLANTS/ ENERGY TECHNOLOGY/ FLOW VELOCITY/ HEAT EXCHANGERS/ POTASSIUM/ TEMPERATURE EFFECTS/ THERMODYNAMIC CYCLES/ THERMODYNAMIC EFFICIENCY

ABA: (Author)

ABS: Low temperature plasmas wherein an alkali metal vapor is a component are uniquely suited to simultaneously absorb solar radiation by coupling to the resonance lines and produce electrical power by the MHD interaction. This work is an examination of the possibility of developing space power systems which take advantage of concentrated solar power to produce electricity. It is shown that efficient cycles in which expansion work takes place at nearly constant top cycle temperature can be devised. The power density of the solar MHD generator is lower than that of conventional MHD generators because of the relatively high seed concentration required for radiation absorption and the lower flow velocity permitted to avoid total pressure losses due to heating.

79N22891# ISSUE 13 PAGE 1777 CATEGORY 75 RPT#:  
VKI-LECTURE-SERIES-B 68/05/00 100 PAGES  
UNCLASSIFIED DOCUMENT DCAF F002628

UTTL: VKI Short Course on Magnetohydrodynamic Accelerators and Generators

AUTH: A/WENDT, J. F. PAT: A/ed.

CORP: Von Karman Inst. for Fluid Dynamics,  
Rhode-Saint-Genese (Belgium). AVAIL NTIS SAP: HC  
05/MF A01

Lecture held at Rhode-Saint-Genese, Belgium, 6-10 May 1968

ANN: After an introduction to the fundamental concepts and equations of magnetohydrodynamics (MHD), the performance of various MHD accelerators and generators and their present day problem areas are discussed. Rectangular channel shapes and the axisymmetric models are included. Diagnostic techniques are treated with emphasis on microwave, magnetic, and electric probes. Continuous electrodeless and pulsed accelerators are presented.

79A39508 ISSUE 16 PAGE 2999 CATEGORY 35 CNT#:  
EX-76-C-01-2341 NSF ENG-76-04116-A01 PROJECT SQUID  
79/00/00 20 PAGES UNCLASSIFIED DOCUMENT

UTTL: Diagnostic techniques in combustion MHD flows

AUTH: A/SELF, S. A. PAA: A/(Stanford University, Stanford, Calif.)

In: Dynamic measurements in unsteady flows; Proceedings of the Dynamic Flow Conference, Marseille, France, September 11-14, 1978 and Baltimore, Md., September 18-21, 1978. (A79-39476 16-35) Skovlunde, Denmark. Proceedings of the Dynamic Flow Conference 1978, 1979. p. 685-704.

MAJS: /\*FLOW MEASUREMENT/\*FUEL COMBUSTION/\*  
MAGNETOHYDRODYNAMIC FLOW/\*MAGNETOHYDRODYNAMIC GENERATORS/\*PLASMA DIAGNOSTICS

MINS: / BOUNDARY LAYERS/ CHANNEL FLOW/ COAL UTILIZATION/ COMBUSTIBLE FLOW/ COMBUSTION EFFICIENCY/ ELECTRON DENSITY (CONCENTRATION)/ ELECTROSTATIC PROBES/ FLUORESCENCE/ GAS TEMPERATURE/ LASER ANEMOMETERS/ SPECTROSCOPY/ THERMODYNAMIC EFFICIENCY/ TURBULENT FLOW / VELOCITY DISTRIBUTION/ WALL FLOW

ABA: V.P.

ABS: The paper deals with an MHD facility designed for flexibility in research into the basic physics of MHD phenomena. The system employs a liquid fuel spray combustor stabilized by counter swirling injection of oxygen and nitrogen. The adaptation of the system to study the thermal efficiency of a combined MHD/steam plant is described. The particular diagnostic measurement needs for understanding and monitoring the performance of combustion MHD generator systems are outlined.

79A42983 ISSUE 18 PAGE 3433 CATEGORY 34  
78/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Design study of coal-fired cored brick regenerative heat exchangers --- for MHD generator

AUTH: A/UPSHAW, G. A.; B/REIHMAN, T. C.; C/TOWNES, H. W. PAA: A/(Boeing Co., Seattle, Wash.); C/(Montana State University, Bozeman, Mont.)

In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978. General Papers, Volume 4. (A79-42973 18-34) Washington, D.C., Hemisphere Publishing Corp., 1978. p. 303-308.

MAJS: /\*COAL UTILIZATION/\*HEAT EXCHANGERS/\*HEATING EQUIPMENT  
/\*MAGNETOHYDRODYNAMIC GENERATORS

MINS: / CERAMICS/ COMPUTERIZED SIMULATION/ DESIGN ANALYSIS/  
ENERGY TECHNOLOGY/ SURFACE ROUGHNESS EFFECTS

ABA: V.T.

ABS: A design study was conducted for cored ceramic brick regenerative heat exchangers for use as air preheaters in coal-fired open cycle magnetohydrodynamic (MHD) power generation systems. Air preheater designs for a 2000 megawatt electrical MHD power plant were analyzed with a computer code that simulated the transient cyclic behavior of the heat exchangers, used local instantaneous ceramic and gas properties, and contained a Nusselt number correlation which included rough surface and entrance effects. The design problem was so formulated that only the reheat inlet velocity and ceramic bed length must be determined to complete design.

79A16492# ISSUE 4 PAGE 706 CATEGORY 75  
78/00/00 59 PAGES UNCLASSIFIED DOCUMENT

UTTL: Plasma diagnostics in an MHD installation  
AUTH: A/SELF, S. A.; B/VASILEVA, I. A.; C/NEFEDOV, A. P.  
In: Open-cycle magnetohydrodynamic electrical power generation. (A79-16478 04-75) Argonne, Ill., Argonne National Laboratory; Moscow, Izdatel'stvo Nauka, 1978, p. 622-680.

MAJS: /\*MAGNETOHYDRODYNAMIC GENERATORS/\*MEASURING INSTRUMENTS/\*PLASMA DIAGNOSTICS/\*WORKING FLUIDS  
MINS: / CHARGED PARTICLES/ COMBUSTION PRODUCTS/ ENERGY TECHNOLOGY/ IONIZED GASES/ PLASMA CONDUCTIVITY/ PLASMA TEMPERATURE

ABA: S.D.

ABS: The plasma parameters that determine the operating efficiency of an MHD generator are the plasma temperature, electrical conductivity, concentration of charged particles, concentration of easily ionized seed atoms, and the velocity and turbulence intensity of the working fluid in the MHD channel. The paper examines methods of measuring the physical parameters of the working fluid of an MHD generator. In all cases, it is important to achieve adequate spatial and temporal resolution for measurements of boundary layer structure and fluctuation amplitudes and spectra. In particular, many of the useful techniques developed for measuring plasma flow properties need refinement and further development in the direction of improved reliability and ease of use. Improved spatial and temporal resolution, and application in the presence of magnetic fields and ash-laden flows.

79A16484# ISSUE 4 PAGE 706 CATEGORY 75  
78/00/00 72 PAGES UNCLASSIFIED DOCUMENT

UTTL: MHD generators --- Faraday, Hall and diagonal generator designs

AUTH: A/LOUIS, J. F.; B/KOVBASIK, V. I.  
In: Open-cycle magnetohydrodynamic electrical power generation. (A79-16478 04-75) Argonne, Ill., Argonne National Laboratory; Moscow, Izdatel'stvo Nauka, 1978, p. 157-226.

MAJS: /\*DESIGN ANALYSIS/\*ENERGY CONVERSION EFFICIENCY/\*ENERGY TECHNOLOGY/\*MAGNETOHYDRODYNAMIC GENERATORS  
MINS: / COMMERCIAL ENERGY/ CONTROL EQUIPMENT/ ELECTRODES/ FARADAY EFFECT/ HALL EFFECT

ABA: S.D.

ABS: Various types of MHD generators are examined, viz. Faraday generator, Hall generator, and diagonal generator. The critical generator fluid mechanics, which affects efficiency and influences design and performance limitations, is discussed. The all-important electrode-insulator problem and MHD channel design considerations are reviewed. Finally, instrumentation and control of MHD generators are considered from an operating standpoint. The present status of generator development is highlighted, and critical design criteria and limitations for building a commercial-scale MHD plant are established.

79A16480# ISSUE 4 PAGE 706 CATEGORY 75  
78/00/00 33 PAGES UNCLASSIFIED DOCUMENT

UTTL: MHD power plant characteristics

AUTH: A/AMEND, W. E.; B/MOROZOV, G. N.  
In: Open-cycle magnetohydrodynamic electrical power generation. (A79-16478 04-75) Argonne, Ill., Argonne National Laboratory; Moscow, Izdatel'stvo Nauka, 1978, p. 16-48.

MAJS: /\*ELECTRIC POWER PLANTS/\*MAGNETOHYDRODYNAMIC GENERATORS/\*POWER EFFICIENCY/\*THERMODYNAMIC CYCLES  
MINS: / COAL UTILIZATION/ ENERGY TECHNOLOGY/ GAS HEATING/ HEATING EQUIPMENT/ TURBOGENERATORS

ABA: S.D.

ABS: The general system features of an MHD power plant are described in terms of process requirements, MHD plant systems and components, and component performance constraints. In addition, basic thermal cycles are outlined, with special emphasis on methods of obtaining high initial temperatures, use of generator exhaust gas heat in low-temperature cycles, effect of regenerative oxidizer preheating on plant efficiency, simplification of high-temperature air preheater systems, compression of the oxidizer, and methods of utilizing low-potential heat. It appears that the use of a high-temperature regenerative preheater is an effective method of increasing efficiency and is especially important in the context of a coal-burning MHD power plant, and that a steam turbine installation is presently considered to represent the best use of combustion products in the bottoming cycle.

79A16488# ISSUE 4 PAGE 706 CATEGORY 75  
78/00/00 74 PAGES UNCLASSIFIED DOCUMENT

UTTL: Fuels and combustion --- for open cycle MHD system

AUTH: A/JOUBERT, J. I.; B/TAGER, S. A.  
In: Open-cycle magnetohydrodynamic electrical power generation. (A79-16478 04-75) Argonne, Ill., Argonne National Laboratory; Moscow, Izdatel'stvo Nauka, 1978, p. 391-464.

MAJS: /\*COMBUSTION CHAMBERS/\*FOSSIL FUELS/\*FUEL COMBUSTION/\*MAGNETOHYDRODYNAMIC GENERATORS  
MINS: / COAL UTILIZATION/ ENERGY TECHNOLOGY/ THERMODYNAMIC CYCLES

ABA: S.D.

ABS: Various aspects of designing open-cycle MHD combustion systems are discussed. The relevant design requirements and thermodynamic considerations for defining combustor operating parameters are presented. The many elements leading to the specification of combustor geometry and hardware are considered, followed by a review of operating experience with experimental combustors. Finally, scale-up considerations are discussed, and the current status of MHD combustor development is assessed.

79A20838 ISSUE 7 PAGE 1147 CATEGORY 27  
78/00/00 9 PAGES UNCLASSIFIED DOCUMENT

UTTL: Preliminary analysis of advanced ceramic magnetohydrodynamic /MHD/ combustor design concepts  
AUTH: A/PAQUETTE, E. L. PAA: A/(Atlantic Research Corp., Alexandria, Va.)

In: Selective application of materials for products and energy: Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 642-650.

MAJS: /\*CERAMICS/\*COMBUSTION CHAMBERS/\*DESIGN ANALYSIS/\*  
MAGNETOHYDRODYNAMIC GENERATORS

MINS: / COOLING/ ENERGY TECHNOLOGY/ FEASIBILITY ANALYSIS/  
MASS TRANSFER

ABA: S.D.

ABS: The following design concepts of advanced ceramic MHD combustors are examined for engineering feasibility: uncooled ceramic-lined combustor, transpirationally cooled ceramic wall combustor, transpirationally shielded or consumable wall ceramic-lined combustors, and steam or air cooled ceramic-lined combustors. Feasible applications of ceramics to these design concepts are discussed. It is shown that the transpirationally cooled or shielded and the consumable wall ceramic-lined combustor concepts are impractical in terms of required flows, material removal rates, economics and reliability. The steam and air cooled ceramic-lined combustors appear to have immediate engineering feasibility. The uncooled ceramic design concept remains viable and essentially dependent on advances in ceramic material development related to selections.

79A33425# ISSUE 13 PAGE 2362 CATEGORY 33  
78/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Consolidation and local control of power in an MHD generator

AUTH: A/LOWENSTEIN, A. PAA: A/(Avco Everett Research Laboratory, Inc., Everett, Mass.)  
In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978. Proceedings. (A79-33379 13-31) Stanford, Calif., Stanford University, 1978, p. 1-6.

ABA: (Author)

ABS: The operating characteristics of two circuits for the consolidation and control of power out of the MHD generator have been studied both analytically and experimentally in tests on the Avco Mark VI. The first circuit utilizes the principle of inductive coupling of electrode currents, which was first suggested by Rosa. The second circuit uses a novel scheme whereby a capacitor provides the required isolation between two electrodes, while power from the two electrodes is delivered to a common point. Two methods of forming cascaded networks for handling a multiple of electrodes using either of these two consolidation elements are also described.

79A33410# ISSUE 13 PAGE 2484 CATEGORY 75 CNT#:  
F33615-76-C-2104 78/00/00 10 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Development of a compact, lightweight high performance 30 MW MHD generator system

AUTH: A/SONJU, O. K.; B/SWALLOW, D. W.; C/NEADER, D. E.; D/BECKER, H.; E/BURRY, R. V.; F/HUEBNER, A. W.; G/COOPER, R. F. PAA: D/(Maxwell Laboratories, Inc., Woburn, Mass.); F/(Rockwell International Corp., Rocketdyne Div., Canoga Park, Calif.); G/(USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio)  
In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978. Proceedings. (A79-33379 13-31) Stanford, Calif., Stanford University, 1978, p. F.5.1-F.5.10.

MAJS: /\*EXPERIMENTAL DESIGN/\*MAGNETOHYDRODYNAMIC GENERATORS  
/\*PERFORMANCE TESTS/\*PORTABLE EQUIPMENT/\*POWER  
EFFICIENCY

MINS: / CHANNEL FLOW/ COMBUSTION EFFICIENCY/ ELECTRODES/  
FUEL COMBUSTION/ FUEL INJECTION/ GRAPHS (CHARTS)/ HEAT  
TRANSMISSION/ HYDROCARBON FUELS/ NOZZLE DESIGN

ABA: (Author)

ABS: This paper describes the current phase of a multiphase program to design, construct, and test a lightweight, high power prototype transportable MHD generator system. The main purpose of this phase is to demonstrate the feasibility of the hot gas flow train components of high performance, lightweight design. In the present program significant advances in terms of such parameters as combustor heat release density, combustion efficiency, channel power density and energy extraction rates are made. The combustion system has a high performance, 160 element injector and the channel was constructed using lightweight electrode frames and a high strength, lightweight glass-fiber wound composite outer wall structure. The results of this phase of the development program that are reported in this paper are part of an overall advancement of the state-of-the-art of compact, lightweight high performance MHD channels and diffusers for transportable burst power MHD generator systems.



79A33400# ISSUE 13 PAGE 2350 CATEGORY 27 CNT#:  
EY-75-C-06-1830 78/00/00 7 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Thermal properties of MHD electrode materials  
AUTH: A/BATES, J. L.; B/MARCHANT, D. D. PAA: B/(Battelle  
Pacific Northwest Laboratories, Richland, Wash.)  
In: Symposium on the Engineering Aspects of  
Magnetohydrodynamics, 17th, Stanford, Calif., March  
27-29, 1978, Proceedings. (A79-33379 13-31) Stanford,  
Calif., Stanford University, 1978, p. D.6.1-D.6.7.  
MAJS: /\*MAGNETOHYDRODYNAMIC GENERATORS/\*PLASMA ELECTRODES/\*  
REFRACTORY MATERIALS/\*THERMOPHYSICAL PROPERTIES  
MINS: / ARC SPRAYING/ CERAMICS/ FABRICATION/ HIGH  
TEMPERATURE/ INSULATORS/ LASER HEATING/ METAL OXIDES/  
MICROSTRUCTURE/ PHASE TRANSFORMATIONS/ POROSITY/  
THERMAL CONDUCTIVITY/ THERMAL DIFFUSIVITY/ THERMAL  
EXPANSION  
ABA: (Author)  
ABS: The thermal conductivity and thermal expansion of a  
number of oxide electrodes and insulators of interest  
to MHD have been measured from 400 to 1850 K. The  
results are summarized and discussed in terms of  
fabrication, microstructure, and phase changes. Arc  
plasma sprayed, sintered, and not pressed materials  
are discussed. Equations for the thermal conductivity  
and the thermal expansion coefficients as functions of  
temperature are given where possible.

79A33396# ISSUE 13 PAGE 2483 CATEGORY 75  
78/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Electrode development for coal fired MHD generators  
AUTH: A/DEMIRJIAN, A.; B/PETTY, S. W.; C/SOLBES, A. PAA:  
C/(Avco Everett Research Laboratory, Inc., Everett,  
Mass.)  
In: Symposium on the Engineering Aspects of  
Magnetohydrodynamics, 17th, Stanford, Calif., March  
27-29, 1978, Proceedings. (A79-33379 13-31) Stanford,  
Calif., Stanford University, 1978, p. D.1.1-D.1.6.  
Research supported by the U.S. Department of Energy.  
MAJS: /\*COAL UTILIZATION/\*MAGNETOHYDRODYNAMIC GENERATORS/\*  
PLASMA ELECTRODES/\*SERVICE LIFE/\*SURFACE PROPERTIES  
MINS: / ANODES/ CATHODES/ COPPER/ ENERGY TECHNOLOGY/  
OXIDATION RESISTANCE/ SLAGS  
ABA: (Author)  
ABS: The paper focuses on two key aspects of the electrode  
wall behavior in slagging linear MHD channels. The  
first problem is related to electrode life-time and  
anodes in particular. The electrode design principle  
is based on the utilization of massive water cooled  
copper current lead outs, capped with oxidation  
resistant materials to minimize anodic erosion. The  
results of numerous cap material tests, conducted in  
the Mark VI facility, are discussed in detail. The  
second aspect characteristic of the operation of  
slagging channel is the development of cathode wall  
non-uniformities. It is shown that these are related  
to slag layer leakage and the salient features of the  
phenomenon are analyzed in detail.

78A35444 ISSUE 14 PAGE 2617 CATEGORY 75  
78/05/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: MHD's target - Payoff by 2000  
AUTH: A/LEVI, E. PAA: A/(New York, Polytechnic Institute,  
Brooklyn, N.Y.)  
IEEE Spectrum, vol. 15, May 1978, p. 46-51.  
MAJS: /\*ENERGY CONVERSION EFFICIENCY/\*HALL EFFECT/\*  
MAGNETOHYDRODYNAMIC GENERATORS/\*PLASMA GENERATORS/\*  
TECHNOLOGICAL FORECASTING  
MINS: / ELECTRIC POWER PLANTS/ ENERGY TECHNOLOGY/ FARADAY  
EFFECT/ LIQUID METALS/ PILOT PLANTS  
ABA: G.R.  
ABS: The magnetohydrodynamic (MHD) technique for generating  
electricity involves the interaction between a  
magnetic field and a conducting medium that is fluid  
rather than solid, as in conventional generators. In  
connection with the desirability to improve the  
efficiency of fuel utilization, programs are being  
conducted in a number of countries to translate the  
MHD concept into a viable, commercially acceptable  
energy-conversion technology. In the U.S. it is  
planned to have an operational pilot plant as early as  
1985, and a base/load commercial demonstration plant  
before 1995. The MHD program in the U.S. emphasizes  
the use of coal in a combined MHD/steam  
energy-conversion system. All the rigid structures in  
MHD generators are stationary. This makes an operation  
at elevated temperatures approaching 3000 K feasible.  
Consequently, higher efficiencies are possible with  
MHD systems than with conventional plants. Attention  
is given to physical constraints, the status of key  
components in the U.S., approaches towards commercial  
demonstration, and aspects of international  
cooperation between the U.S. and the U.S.S.R.

78A40509 ISSUE 17 PAGE 3121 CATEGORY 44  
78/06/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Large superconducting magnets - A key issue in commercialization of MHD  
AUTH: A/OVCHARENKO, V. A. PAA: A/(United Nations, Centre for Natural Resources, Energy and Transport, New York, N.Y.)  
Cryogenics, vol. 18, June 1978, p. 358-362.  
MAJS: /\*ECONOMIC ANALYSIS/\*MAGNETOHYDRODYNAMIC GENERATORS/\*  
SUPERCONDUCTING MAGNETS/\*TECHNOLOGY ASSESSMENT  
MINS: / ELECTRIC POWER SUPPLIES/ ENERGY CONVERSION/  
ENVIRONMENT PROTECTION/ FIELD COILS/ PILOT PLANTS/  
U.S.S.R.

ABA: D.M.W.

ABS: Basic principles of the design and operation of large superconducting magnets in MHD generators are reviewed with reference to economic and environmental factors. It is noted that MHD plants are considerably more efficient than conventional plants in that they reject only one unit of heat per unit of generated electricity (thereby, also, reducing thermal pollution). Two types of MHD magnets are compared, saddle and race track, in terms of maximum channel field, dimensions, cold weight, and operational status. Attention is given to the U-25 pilot plant in the USSR, which is expected to produce 600 MW using magnetic field of 6 T inlet, and 3.5 T outlet.

78A24329 ISSUE 8 PAGE 1417 CATEGORY 44  
78/02/00 3 PAGES UNCLASSIFIED DOCUMENT

UTTL: MHD electric power generation --- using fossil fuels  
AUTH: A/DETRA, R. W. PAA: A/(Avco Everett Research Laboratory, Inc., Everett, Mass.)  
Energy, vol. 3, Winter 1978, p. 21-23.  
MAJS: /\*COAL UTILIZATION/\*COMBUSTION EFFICIENCY/\*ELECTRIC  
POWER PLANTS/\*MAGNETOHYDRODYNAMIC GENERATORS/\*  
TECHNOLOGY UTILIZATION  
MINS: / ENERGY CONVERSION EFFICIENCY/ NITROGEN OXIDES/ PILOT  
PLANTS/ POLLUTION CONTROL  
ABA: D.M.W.

ABS: Faraday's law of induction provides the principle for the operation of a magnetohydrodynamic (MHD) generator for the production of electricity from fossil fuels, i.e., coal. Tests conducted with a mini-MHD with an average output of 300 kW reveal that the extremely high operating temperatures of the system (4500-5000 F) yield high efficiency in energy production, while reducing by half the amount of coal used to produce the energy, and reducing by 90% sulfur and NOx emissions. The high temperatures can be maintained because the whole surface of the MHD can be exposed to cooling. In addition, potassium carbonate seeding is used to fix pollutants in the combustion gases, lowering their rate of emission into the atmosphere still further.

79A16481# ISSUE 4 PAGE 706 CATEGORY 75  
78/00/00 39 PAGES UNCLASSIFIED DOCUMENT

UTTL: Layout and design characteristics of MHD power stations  
AUTH: A/HALS, F. A.; B/MOROZOV, G. N.  
In: Open-cycle magnetohydrodynamic electrical power generation. (A79-16478 04-75) Argonne, Ill., Argonne National Laboratory; Moscow, Izdatel'stvo Nauka, 1978, p. 49-87.  
MAJS: /\*DESIGN ANALYSIS/\*ELECTRIC POWER PLANTS/\*LAYOUTS/\*  
MAGNETOHYDRODYNAMIC GENERATORS/\*TURBOGENERATORS  
MINS: / COAL UTILIZATION/ ECONOMIC FACTORS/ ENERGY  
TECHNOLOGY/ ENGINE DESIGN/ THERMODYNAMIC CYCLES  
ABA: S.D.

ABS: The advantages and disadvantages of different open-cycle MHD plant layouts that have been proposed are reviewed and discussed. The layouts depict plants with both horizontal and vertical MHD generators and with different turbine arrangements. Turbine arrangement, however, is not critical in generator layout in either case. Methods of removing the channel from the magnet system are presented. Basic design characteristics of a first-generation gas- or oil-fired MHD power station as well as of a coal-fired MHD power station are described. Structural diagrams of a first-generation MHD power plant fired by natural gas and of a coal-fired MHD power plant are presented and discussed. It is suggested that MHD power stations will have large power outputs, probably of the order of 2000 MW electrical power, and that the economics become more favorable as unit sizes increase. Such stations may also be used as cogeneration plants where appropriate. The horizontal arrangement of the MHD generator seems the most logical.

78A40834# ISSUE 17 PAGE 3191 CATEGORY 75  
78/07/00 7 PAGES UNCLASSIFIED DOCUMENT

UTTL: Optimization of the current profile in MHD generators  
AUTH: A/RAMBERGER, R. PAA: A/(Innsbruck, Universitaet, Innsbruck, Austria)  
AIAA Journal, vol. 16, July 1978, p. 740-746.  
Research supported by the Scientific and Industrial Austrian Research Councils.  
ABA: (Author)

ABS: A method is discussed to reduce the extremely high current density at certain ends of the electrodes in a Faraday MHD generator caused by the Hall effect. To begin with, criteria are developed for improving the electric current profile. With the help of these criteria, a variational principle is formulated for numerically obtaining the 'optimal' profile for fixed gasdynamic flow. This optimum is compromising between maximal uniformity of the current pattern and the minimal electrode losses. It can be realized by choosing a suitable conductivity profile in the electrodes. The results of the numerical optimization with the finite element method show that it is indeed possible to achieve a reduction of the current concentration, but only to a certain extent, in order to avoid high potential drops in the electrodes



80N128B2# ISSUE 3 PAGE 395 CATEGORY 75 RPT#:  
AD-A073128 ANL/MHD-79-1 CNT#; N00014-78-1-0004  
79/04/00 214 PAGES UNCLASSIFIED DOCUMENT

UTTL: Experimental two-phase liquid-metal  
magnetohydrodynamic generator program TLSP: Final  
Report, Oct. 1977 - Sep. 1978  
AUTH: A/PETRICK, M.; B/FABRIS, G.; C/PIERSON, E. S.;  
D/FISCHER, A. K.; E/JOHNSON, C. E.  
CORP: Argonne National Lab., Ill. CSS: (Engineering Div.)  
AVAIL NTIS SAP: HC A10/MF A01  
MAJS: /\*LIQUID METALS/\*MAGNETOHYDRODYNAMIC GENERATORS/\*TWO  
PHASE FLOW  
MINS: / ELECTRIC POWER SUPPLIES/ ENERGY CONVERSION  
EFFICIENCY/ FLOW CHARACTERISTICS/ LIQUID-VAPOR  
INTERFACES/ PERFORMANCE PREDICTION  
ABA: GRA  
ABS: The experimental results presented herein satisfy one  
major goal in demonstrating the technical feasibility  
of two-phase LMMHD (liquid-metal MHD), i.e., operating  
an MHD generator at power densities equal to or above  
that anticipated for practical power systems. Power  
densities of up to 32 MWe/m(3) and efficiencies higher  
than 0.6 at high void fractions were attained for a  
small 20 kWe generator. Slip ratio data, and more  
extensive pressure distribution and voltage profile  
data are also given. Barium has been identified as an  
attractive additive for the generation of foams with  
NaK, and bismuth is a back-up for barium. A guiding  
hypothesis for understanding the phenomena  
contributing to foamability in liquid metal systems  
has been developed, and basic data on surface tension  
obtained.

TA National SMPE Symposium and Exhibition, 23rd,  
418.9 Anaheim, Calif., 1978.

.C6 Selective application of materials for  
A3 products and energy ... c1978.

1978 (Card 2)

Includes bibliographical references and  
index.

1. Materials--Congresses. I. Society  
for the Advancement of Material and Process

PRELIMINARY ANALYSIS OF ADVANCED CERAMIC MAGNETOHYDRODYNAMIC 642-SS  
(MHD) COMBUSTOR DESIGN CONCEPTS

Edward L. Paquette

79A15305\* ISSUE 4 PAGE 583 CATEGORY 33 CNT#:  
NAS3-19885 78/00/00 9 PAGES UNCLASSIFIED DOCUMENT

UTTL: Design study of superconducting magnets for a  
combustion magnetohydrodynamic /MHD/ generator  
AUTH: A/THOME, R. J.; B/AYERS, J. W.; C/HRYCAJ, T. M.;  
D/BURKHART, J. A. PAA: C/(Magnetic Corporation of  
America, Waltham, Mass.); D/(NASA, Lewis Research  
Center, Cleveland, Ohio)  
CORP: Magnetic Corp. of America, Waltham, Mass.; National  
Aeronautics and Space Administration, Lewis Research  
Center, Cleveland, Ohio.  
In: Advances in cryogenic engineering. Volume 23 -  
Proceedings of the Conference, Boulder, Colo., August  
2-5, 1977. (A79-15301 04-31) New York, Plenum Press,  
1978, p. 28-36.  
MAJS: /\*CRYOGENIC MAGNETS/\*MAGNETOHYDRODYNAMIC GENERATORS/\*  
SUPERCONDUCTING MAGNETS/\*TEST FACILITIES  
MINS: / DESIGN ANALYSIS/ ENERGY TECHNOLOGY/ MAGNET COILS/  
NIOBIUM ALLOYS/ TRADEOFFS  
ABA: S.D.  
ABS: Results are presented for a trade-off and preliminary  
design study on concepts of a superconducting magnet  
system for a combustion MHD generator test facility.  
The main objective is to gain insight into the  
magnitude of the project in terms of physical  
characteristics and cost. The net result of a  
first-phase evaluation of attractive design  
alternatives is to concentrate subsequent efforts on  
(1) a racetrack coil geometry with an operating  
temperature of 4.2 K, (2) a racetrack coil geometry  
with an operating temperature of 2.0 K, and (3) a  
rectangular saddle coil geometry with an operating  
temperature of 4.2 K. All three systems are to produce  
8 T, and use NbTi superconductor and iron for field  
enhancement. Design characteristics of the three  
systems are described. It is shown that the racetrack  
and rectangular saddle coil geometries seem most  
suitable for this application, the former because of  
its simplicity and the latter because of its efficient  
use of material. Advantages of the rectangular saddle  
over the two other systems are stressed.

BOA16254# ISSUE 4 PAGE 674 CATEGORY 75

79/09/00 19 PAGES UNCLASSIFIED DOCUMENT

UTTL: The physics of closed cycle MHD power generation  
AUTH: A/RIETJENS, L. H. T. PAA: A/(Eindhoven, Technische Hogeschool, Eindhoven, Netherlands)

In: The physics of ionized gases: Summer School, 9th and Symposium, Dubrovnik, Yugoslavia, August 28-September 2, 1978, Invited Lectures and Progress Reports, (A80-16251 04-75) Belgrade, Institut za Fiziku, 1979, p. 753-771.

MAJS: /\*CLOSED CYCLES/\*ELECTRIC POWER PLANTS/\*  
MAGNETOHYDRODYNAMIC GENERATORS/\*PLASMA PHYSICS

MINS: / ENERGY TECHNOLOGY/ IMPURITIES/ SHOCK TUBES/  
STAGNATION TEMPERATURE/ STEAM

ABA: V.P.

ABS: A historical review of research work in MHD power generation is followed by a discussion of the principle of an MHD steam power plant. The physics of closed cycle MHD power generation is outlined, and means of eliminating, or drastically reducing, all losses not inherent to the actual MHD conversion processes are examined. The problem of modelling the plasma in the MHD generator is analyzed.

79A20532 ISSUE 7 PAGE 1149 CATEGORY 31

79/01/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: Design and operating experience of the cryogenic system of the U.S. SCMS as incorporated into the bypass loop of the U-25 MHD generator facility --- Superconducting Magnet System

AUTH: A/NIEMANN, R. C.; B/MATAYA, K. F.; C/MCWILLIAMS, D. A.; D/BORDEN, R.; E/STREETER, M. H.; F/WICKSON, R.; G/PRIVALOV, N. P.; H/SMELSER, P. PAA: B/(Argonne National Laboratory, Argonne, Ill.); F/(CTI-Cryogenics, Sudbury, Mass.); G/(Akademika Nauk SSSR, Nauchno-Issledovatel'skii Institut Vysokikh Temperatur, Moscow, USSR)

(Applied Superconductivity Conference, Pittsburgh, Pa., Sept. 25-28, 1978.) IEEE Transactions on Magnetics, vol. MAG-15, Jan. 1979, p. 298-301.

Research supported by the U.S. Department of Energy.

MAJS: /\*COOLING SYSTEMS/\*CRYOGENICS/\*MAGNETOHYDRODYNAMIC GENERATORS/\*OPERATIONAL PROBLEMS/\*SUPERCONDUCTING MAGNETS/\*SYSTEMS ENGINEERING

MINS: / ENERGY TECHNOLOGY/ HIGH FIELD MAGNETS/ INTERNATIONAL COOPERATION/ LIQUID HELIUM/ UNITED STATES OF AMERICA

79A20535 ISSUE 7 PAGE 1154 CATEGORY 33

79/01/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: Practical aspects of designing and manufacturing MHD superconducting base-load magnets in 1988 time frame

AUTH: A/ACKERMAN, S. L.; B/ROYE, C. E.; C/RANDALL, R. N.; D/RAPPERPORT, E. J. PAA: B/(General Dynamics Corp., Convair Div., San Diego, Calif.); C/(Supercon, Inc., Natick, Mass.); D/(Magnetic Engineering Associates, Boston, Mass.)

(Applied Superconductivity Conference, Pittsburgh, Pa., Sept. 25-28, 1978.) IEEE Transactions on Magnetics, vol. MAG-15, Jan. 1979, p. 310-313.

MAJS: /\*MAGNETOHYDRODYNAMIC GENERATORS/\*PRODUCTION ENGINEERING/\*STRUCTURAL DESIGN/\*SUPERCONDUCTING MAGNETS/\*TECHNOLOGICAL FORECASTING

MINS: / COST REDUCTION/ CRYOGENICS/ DESIGN ANALYSIS/ ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY/ HIGH FIELD MAGNETS/ SUBSTRUCTURES

ABA: P.T.H.

ABS: Manufacturing alternatives for three base-load MHD superconducting magnets are discussed. The three designs are two circular saddle concepts and a rectangular saddle concept. They are discussed with respect to insulation, substructure and superstructure, and final assembly operation. The circular design deals with force containment in a more direct manner, utilizing the straight-line tensile paths of the shells and stave as opposed to the large moment generation inherent in the rectangular design. All three concepts use similar manufacturing methods, but circular designs minimize or simplify the respective manufacturing methods and result in better efficiency and lower cost.

79A32349# ISSUE 13 PAGE 2401 CATEGORY 44 RPT#:  
ASME PAPER 79-GT-54 79/03/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Energy conversion by means of MHD shock-wave generators combined with closed-cycle gas turbines

AUTH: A/STINGELIN, V.; B/BUDLIGER, J. P. PAA: B/(Battelle, Geneva, Switzerland) SAP: MEMBERS, \$1.50; NONMEMBERS, \$3.00

American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, 5 p.

MAJS: /\*CLOSED CYCLES/\*ENERGY CONVERSION EFFICIENCY/\*GAS TURBINE ENGINES/\*MAGNETOHYDRODYNAMIC GENERATORS/\*SHOCK WAVE INTERACTION

MINS: / ENGINE INLETS/ GAS TEMPERATURE/ HEAT SOURCES/ SHOCK HEATING/ THERMODYNAMIC EFFICIENCY

ABA: (Author)

ABS: The principle of the operation and the basic features of shock-wave MHD generators are described. Such generators may serve as topping devices to closed-cycle gas turbines, giving the possibility of using heat source temperatures of a few hundred degrees in excess to the inlet temperatures to the gas turbines. Cycle efficiencies and specific power ratings can be increased considerably by means of such topping devices.

79A33409# ISSUE 13 PAGE 2484 CATEGORY 75  
78/00/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Detailed characterization of MHD generator operating parameters

AUTH: A/KESSLER, R.; B/SOLBES, A. PAA: B/(AVCO Everett Research Laboratory, Inc., Everett, Mass.)  
In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978. Proceedings. (A79-33379 13-31) Stanford, Calif., Stanford University, 1978. p. F.4.1-F.4.8. Research supported by the U.S. Department of Energy.

MAJS: /\*ELECTRICAL MEASUREMENT/\*HEAT FLUX/\*  
MAGNETOHYDRODYNAMIC GENERATORS/\*PERFORMANCE TESTS/\*  
VOLT-AMPERE CHARACTERISTICS

MINS: / BOUNDARY LAYERS/ COMBUSTION CHAMBERS/ ELECTRIC  
POTENTIAL/ ELECTROCONDUCTIVITY/ FARADAY EFFECT/ HALL  
EFFECT/ PLASMA ELECTRODES

ABA: (Author)

ABS: Experiments were conducted to investigate detailed operating characteristics of combustion-driven slagging MHD generators. Performance characteristics of two different generators are compared. One generator was built with conventional flat electrode walls, and the other had V-shaped electrode walls. Both generators had peg-type insulator walls which were used for detailed electrical diagnostics. The generators had identical lofting and both were operated over a similar range of gas conditions, magnetic-field intensities, and electrical loading. The V-wall generator had higher voltage drops at both electrode walls and produced less power at given values of gas electrical conductivity and magnetic field. Detailed heat-transfer measurements were made in the flat-wall channel under both power-generating and non-power-generating conditions. Under power-generating conditions, heat transfer to both cathode and anode walls increased significantly. Heat transfer was measured to an electrode pair that was not drawing current but was located downstream of a large number of electrodes that were drawing current. The open-circuited electrode pair experienced increased heat flux compared with the case in which the upstream electrodes drew no current.

79N25499# ISSUE 16 PAGE 2145 CATEGORY 44  
RPT#: NASA-TM-79140 DOE/NASA/2674-79/4 E-9987 CNT#: EF-77-A-01-2674 79/00/00 32 PAGES UNCLASSIFIED DOCUMENT

UTTL: MHD performance calculations with oxygen enrichment

AUTH: A/PIAN, C. C. P.; B/STAIGER, P. J.; C/SEIKEL, G. R.  
CORP: National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. AVAIL:NTIS SAP: HC A03/MF A01

Presented at 18th Symp. on Engineering Aspects of Magnetohydrodynamics, Butte, Montana, 18-20 Jun. 1979

MAJS: /\*MAGNETOHYDRODYNAMIC GENERATORS/\*OXYGEN/\*POWER  
EFFICIENCY

MINS: / ENERGY CONVERSION EFFICIENCY/ ENRICHMENT

ABA: Author

ABS: The impact of oxygen enrichment of the combustion air on the generator and overall plant performance was studied for the ECAS-scale MHD/steam plants. A channel optimization technique is described and the results of generator performance calculations using this technique are presented. Performance maps were generated to assess the impact of various generator parameters. Directly and separately preheated plant performance with varying O<sub>2</sub> enrichment was calculated. The optimal level of enrichment was a function of plant type and preheat temperature. The sensitivity of

79N20518# ISSUE 11 PAGE 1450 CATEGORY 44 RPT#: FE-3087-2 CNT#: ET-78 C-01-3087 78/06/00 209 PAGES UNCLASSIFIED DOCUMENT

UTTL: MHD power generation: Research, development and engineering TLSP: Quarterly Progress Report, Apr. - Jun. 1978

CORP: Montana Energy and MHD Research and Development Inst., Inc., Butte. AVAIL:NTIS SAP: HC A10/MF A01

MAJS: /\*CERAMICS/\*DEGRADATION/\*MAGNETOHYDRODYNAMIC  
GENERATORS/\*REFRACTORY MATERIALS/\*RESEARCH

MINS: / COAL UTILIZATION/ ENVIRONMENT EFFECTS/ GRAPHS  
(CHARTS)/ REPORTS/ SYSTEMS ANALYSIS/ SYSTEMS  
ENGINEERING/ TABLES (DATA)

ABA: G.Y.

ABS: The Montana Energy and MHD Research and Development Institute (MERDI) was established in Butte, Montana in 1974 to develop methods for conserving western energy sources and to carry out supporting science and technology tasks for the national magnetohydrodynamic (MHD) program. Under contract to the U.S. Department of Energy, these tasks were divided among researchers at MERDI, the Montana Colleges of Mineral Science and Technology (MCMST), and Montana State University (MSU). The work accomplished by MERDI, MCMST, and MSU from April through June 1978 are summarized.



## MHD HEAT TRANSFER PROBLEMS - AN OVERVIEW

A. W. Postlethwaite and M. M. Slutyer

Mechanical Engineering, vol. 100, no. 3, March 1978  
p. 32-39

*Research in the field of magnetohydrodynamics (MHD) has advanced to the point where the development of an operational system is feasible. The primary system being considered by ERDA is an open-cycle MHD/steam cycle power loop. Critical thermal problems affect the system due to hot ionized plasma, seed injection, slag deposition, and high-temperature air heaters. MHD power generation has entered the development phase and commercial operation can be achieved by existing materials and techniques.*

EXPERIMENTAL STUDIES OF A LINEAR MHD GENERATOR WITH FULLY IONIZED SEED, by H. Yamasaki, Y. Masuhara, and S. Shioda.

Journal of Energy, vol. 2, no. 6, Nov.-Dec. 1978,  
p. 337-341.

Power generation experiments for a linear nonequilibrium Faraday generator with small seed fractions of  $10^{-5}$  to  $10^{-4}$  have been conducted in order to show the recovery of the effective electrical conductivity and the power density due to the suppression of ionization instability and to demonstrate the possible operation of a linear MHD generator with fully ionized seed. Results of the present experiments have shown the recovery of the apparent conductivity up to 20-27 mho/m, and the ratio of the apparent conductivity to the ideal conductivity decreases from 0.8 to 0.2 as the seed fraction increases from  $1 \times 10^{-5}$  to  $7 \times 10^{-5}$ . The high apparent conductivity indicates the possible operation of a linear generator with fully ionized seed, and the increase of isentropic efficiency of a closed-cycle inert-gas MHD generator can be expected.

## MAGNETOHYDRODYNAMIC/STEAM POWER PLANT MODELING AND CONTROL, by John D. Aspnes and Donald A. Pierre.

Energy Conversion, vol. 18, no. 2, 1978, p. 101-113.

**Abstract** A dynamic power flow simulation of an overall magnetohydrodynamic (MHD) steam electrical power generating plant is developed. Time domain solutions to the set of system equations are given. Several control configurations are applied to the system and their effects on system dynamic response are presented. The overall combined cycle system model utilizes an input-output characterization of the Combustor/Nozzle/Channel Diffuser. This characterization is developed from polynomial approximations of data resulting from the solutions of energy balance, state, and continuity equations for the combustor and the quasi one-dimensional MHD equations for the nozzle, channel and diffuser. The boiler and turbine valve model has turbine valve area and power available to generate steam as inputs, and throttle pressure, power to the turbines, and boiler and stack losses as outputs. Regenerative air preheater cycling is also modeled, and the effect of cycling on plant output is given.

**Controls** Energy conversion Combined cycle electric power plant Magnetohydrodynamic generator Computer simulation Dynamic system modeling

79N24446\*# ISSUE 15 PAGE 2000 CATEGORY 44  
RPT#: NASA-TM-79172 DOE/NASA/2674 79/5 E-036 CNT#:  
EF-77-A-01-2674 79/00/00 12 PAGES UNCLASSIFIED  
DOCUMENT

UTIL: Performance optimization of an MHD generator with physical constraints

AUTH: A/PIAN, C. C. P.; B/SEIKEL, G. R.; C/SMITH, J. M.

CORP: National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. AVAIL NTIS SAP: HC A02/ME A01

Proposed for presentation at 14th Intersoc. Energy Conversion Eng. Conf., Boston, 5-10 Aug. 1979

MAJS: /-MAGNETOHYDRODYNAMIC GENERATORS/ OPTIMIZATION  
MINS: / BOILERS/ PARAMETERIZATION/ PERFORMANCE TEST

AEA: Author

ABS: A method to optimize the Faraday MHD generator performance under a prescribed set of electrical and magnet constraints is described. The results of generator performance calculations using this technique are presented for a very large MHD/steam plant. The differences between the maximum power and maximum net power generators are described. The sensitivity of the generator performance to the various operational parameters are presented. overall plant performance to critical channel assumptions and oxygen plant performance characteristics was also examined.

EFFECT OF NONIDEAL CONDITIONS ON THE ELECTRICAL PERFORMANCE OF FARADAY MHD GENERATORS. R. Jayakumar, D.K. Goyal, S. Ghosh and V.K. Rohatka.

International Journal of Energy Research, vol 2, no 3 July-September 1978, p. 265-280.

The effect of nonideal conditions on the current flow in a MHD generator has been investigated by two-dimensional analysis in terms of internal resistance, Hall voltage and uniformity of current distribution. In particular, the effects of (a) temperature profile along the Faraday direction in the plasma, (b) current bunching on cathode surfaces due to phenomena like arc spots, and (c) electrical leakage between adjacent electrodes due to finite resistance of the insulator segments are investigated. The results show that cold boundary layers near metallic electrode surfaces tend to relieve current concentration. The optimum resistivity of wedge-shaped electrodes for obtaining uniform current distribution in the duct has been calculated for various temperature profiles. The results indicate that the internal resistance of a MHD generator strongly depends on the location and size of current bunched spots on cathodes. The fluctuations in the spot size and its location can lead to large fluctuations in power output. The present calculations reveal that the electrical performance of a MHD generator is not adversely affected by current leakage along insulator segments for small insulator conductivities.

PERFORMANCE OF DISK GENERATORS FOR OPEN-CYCLE MHD POWER GENERATION. T. Nakamura and M. K. Jenkins.

Journal of Energy, vol 3, no 4, July-August 1979, p. 217-226.

The performance characteristics of disk MHD generators are analyzed for the combustion products of a Western coal at typical baseload conditions. Three disk generator configurations—radial outflow, radial inflow, and radial inflow-outflow—are considered for both impulse and reaction modes of operation. It is shown for enthalpy extraction, generator isentropic efficiency, and electric fields to be sustained along the generator channel, that the reaction mode radial inflow configuration is preferable for the baseload disk generator. The radial inflow-outflow configuration, which is a combination of the inflow and outflow geometries, could attain higher performance than the radial inflow configuration with substantially reduced generator size. Comparisons of disk generators with linear generators show that the performance of the disk generator is comparable to that of the diagonal generator, while the magnet cost for the disk generator is expected to be less than for linear generators. In view of these results, together with the advantages associated with simple channel construction, it is concluded that the disk generator is a potentially effective alternative to linear generators for baseload power generation.

A80 25102 # The retrofit approach to MHD demonstration and commercialization. J. W. Griswold, J. W. Moyer, and M. C. Wehrey (Southern California Edison Co., Los Angeles, Calif.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 18th, Butte, Mont., June 18-20, 1979, Preprints. (A80 25061 09 31) Bozeman, Mont., Montana State University, 1979, p. H.3.1-H.3.8. 7 refs.

The paper presents the retrofit approach as a means to demonstrate MHD technology. The anticipated benefits of retrofit are discussed along with some ground rules from a utility point of view, the key decisions to be made, the retrofit path to demonstration, and an opinion on the potential market for MHD retrofit installations. V.T.

A80 25104 # The transition MHD power plant concept. S. Way. In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 18th, Butte, Mont., June 18-20, 1979, Preprints. (A80 25061 09 31) Bozeman, Mont., Montana State University, 1979, p. H.6.1-H.6.6. 8 refs.

In order to hasten the realization of commercial MHD power generation, with its attendant benefits, a transition type power plant may be designed and constructed. The plant could meet the needs for preliminary pilot plant experience, and could then evolve into a functioning commercial power installation. Its projected size would be 172 MW net electrical output, and station efficiency would be 43-44%. The MHD-dc power generated would be 80 MW. Initial operation at 50 MW-MHD power, instead of the normal 80 MW, would furnish preliminary experience. Under those conditions the top temperature would be reduced, and air preheat would be 1320 K instead of 1348 K. The MHD system is combined with a simple non-reheat steam bottom plant, which can be operated alone when the MHD generator is out of service. (Author)

BOA14530 ISSUE 3 PAGE 482 CATEGORY 75 79/07/00 7 PAGES UNCLASSIFIED DOCUMENT

UTTL: Some problems with variable operation of an MHD generator

AUTH: A/VELIKOV, V. V.; B/BREEV, V. V.; C/GUBAREV, A. V.; D/ZOTOV, A. V. (Magnitnaya Gidrodinamika, Jan.-Mar. 1979, p. 89-96.) Magnetohydrodynamics, vol. 15, no. 1, July 1979, p. 73-79. Translation.

MAJS: /-ENERGY CONVERSION EFFICIENCY/ MAGNETOHYDRODYNAMIC GENERATORS/ VOLT-AMPERE CHARACTERISTICS

MINS: / DIFFERENTIAL EQUATIONS/ MAGNETIC COILS/ NONLINEAR EQUATIONS/ SUPERSONIC FLOW/ TRANSIENT RESPONSE

ABS: (For abstract see issue 14, p. 2661, Accession no. A79-35601)

A80 25101 # Preliminary assessment of the requirements and potential of open cycle MHD as an electric utility power plant. F. D. Retallick, D. A. McCutchan, T. E. Lippert, and K. D. Le (Westinghouse Electric Corp., Pittsburgh, Pa.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 18th, Butte, Mont., June 18-20, 1979, Preprints. (A80 25061 09 31) Bozeman, Mont., Montana State University, 1979, p. H.2.1-H.2.5.

Commercialization of MHD will be contingent on three major factors: performance, plant availability and economics. These three factors are interrelated in a complex manner in the electric utility environment. Simulation of this environment has been performed as a guide to MHD power plant development. The worth of availability is found to be between 10-20 \$/AWe depending on the specific utility characteristic. MHD duct lifetime requirements for attaining competitive power plant availability are a strong function of the cycle arrangement (method of preheat and/or oxygen enrichment) and the duct replacement time, varying between 2500 to 9700 hours as extremes. Significant reductions in these requirements may be possible with simultaneous operation of dual channels, each having a capability in excess of 50% of the power plant rating. Market penetration analysis of MHD by geographic region of the U.S. between 1995-2000 shows a major potential for MHD. The geographic region and coal type have been classified as favorable, marginal or

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OF POOR QUALITY



# IMPROVEMENT OF CHARACTERISTICS OF NONEQUILIBRIUM MHD GENERATOR BY APPLYING CURRENT PARALLEL TO MAGNETIC FIELD

D. Tanaka and Y. Hattori

Energy Conversion, vol 19, no. 2, 1979, pp. 91-99.

**Abstract**—Quasi three-dimensional analysis is made to estimate effects of applied current parallel to magnetic field on the characteristics of nonequilibrium Faraday MHD generator. Potassium-seeded argon plasma at 1500 K and 10 atm is assumed. Resistive power-extraction electrode is taken into account to reduce the current concentration phenomena occurring at electrode edges. The applied current parallel to magnetic field enlarges the stable region free from ionization instability. The net output power exceeds the power obtained for the case of no applied current in the limited ranges of applied current and Hall parameter. The resistive power-extraction electrode is useful to successfully prevent the applied current from short-circuiting along the electrode surface.

## THE ROLE OF INTERFACIAL HEAT AND MECHANICAL ENERGY TRANSFERS IN A LIQUID-METAL MHD GENERATOR.

G. Fabris and E. S. Pierson.

Energy Conversion an International Journal, vol 19, no 2, 1979, p. 111-119.

**Abstract**—A brief description of the two-phase liquid-metal MHD power generation cycle and its advantages is provided. The importance of good interfacial liquid to gas heat transfer is discussed, and data confirming that satisfactory heat transfer is indeed achieved in an experimental generator is presented. An expression for the effect of the velocity difference between the gas and the liquid on generator performance is derived. An 'equivalent turbine' efficiency is defined to characterize the generator as part of a heat engine and related to experimental data.

## THE FUTURE FOR MHD POWER GENERATION. L. H. Th Rietjens.

Physics in Technology, vol 10, no 5, September 1979, p. 216-221.

**Magnetohydrodynamics for electricity generation could lead to greater efficiencies in extracting energy from fossil fuels. In Russia, work has already started on a commercial MHD power plant**

79A52968 ISSUE 24 PAGE 4555 CATEGORY 45 CNT#:  
EP-78-C-02-4651 EF-77-C-01-2430 79/10/00 6 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: MHD emissions and their controls  
AUTH: A/MATRAY, P.; B/HUDDLESTON, G. FAA: B/(Montana Energy and MHD Research and Development Institute, Inc., Butte, Mont.)  
Environmental Science and Technology, vol. 13, Oct. 1979, p. 1208-1213.

MAJS: /\*COAL UTILIZATION/\*COMBUSTION PRODUCTS/\*ELECTRIC POWER PLANTS/\*ENVIRONMENT \*POLLUTION/\*  
MAGNETOHYDRODYNAMIC GENERATORS/\*POLLUTION CONTROL  
MINS: / EFFLUENTS/ ENERGY TECHNOLOGY/ ENVIRONMENTAL MONITORING/ NITROGEN OXIDES/ SOLID WASTES/ SULFUR DIOXIDES/ TRACE ELEMENTS

ABA: C.F.W.

ABS: The use of magnetohydrodynamics (MHD) as a new energy technology due to its efficiency and cost-effectiveness is examined. Three major goals of the DOE are discussed, which include (1) achieving overall coal-to-busbar efficiencies near 50% in MHD demonstration facilities, (2) demonstrating the economic feasibility of MHD, and (3) meeting environmental emission standards for sulfur dioxide, nitrogen oxides, and particulates. Attention is given to MHD generated wastes such as seed, fly ash, and slag, and those generated by conventional coal-fired power plants. The three major EPA regulations which affect air quality, such as NSPS, PSD, and the National Ambient Air Quality Standards (NAAQS) are discussed and their bearing on the development of MHD is noted.

## POWER OUTPUT OF AN MHD GENERATOR EFFECT OF IONIZATION INSTABILITY AND BOUNDARY LAYER. M. S. Sodha and B. K. Gupta.

Energy Conversion an International Journal, vol 19, no 2, 1979, p. 119-124.

**Abstract**—This paper presents an investigation of the effect of ionization instability on effective conductivity and power output of an MHD generator in the presence of velocity temperature boundary layer. Analysis is based on a phenomenological approach. It is concluded that the ratio of power output (in the presence of ionization instability) to the power output (without ionization instability) increases with an increase in the boundary layer thickness. Effective conductivity and power output both are found to decrease with the increasing magnetic field.

ABO 11972\* Survey of MHD plant applications, J. J. Lynch (U.S. Department of Energy, Washington, D.C.), G. R. Seikel (NASA, Lewis Research Center, Cleveland, Ohio), and J. C. Cutting (Gilbert/Commonwealth, Inc., Reading, Pa.) In: Energy technology VI: Achievements in perspective, Proceedings of the Sixth Conference, Washington, D.C., February 26-28, 1979. (ABO 11953 02 44) Washington, D.C., Government Institutes, Inc., 1979, p. 793807, 24 refs.

Open-cycle MHD is one of the major R&D efforts in the Department of Energy's program to meet the national goal of reducing U.S. dependence on oil through increased utilization of coal. MHD offers an effective way to use coal to produce electric power at low cost in a highly efficient and environmentally acceptable manner. Open-cycle MHD plants are categorized by the MHD combustor oxidizer, its temperature and the method of preheat. The paper discusses MHD baseline plant design, open cycle MHD plant in the Energy Conversion Alternatives Study (ECAS), early commercial MHD plants, conceptual studies of the engineering test facility, retrofit (addition of an MHD topping cycle to an existing steam plant), and other potential applications and concepts. Emphasis is placed on a survey of both completed and ongoing studies to define both commercial and pilot plant design, cost, and performance. S.D.

N80 18559\*# Avco Corp., Wilmington, Mass.  
**PARAMETRIC STUDY OF POTENTIAL EARLY COMMERCIAL MHD POWER PLANTS** Final Report  
Finn A. Hals. Dec. 1979. 246 p. refs.  
(Contracts DEN3 51, EF-77 A-01-2674)  
(NASA CR 159633, DOE/NASA/0051-79/1) Avail NTIS HC A11/MI A01 CSCL 10B

Three different reference power plant configurations were considered with parametric variations of the various design parameters for each plant. Two of the reference plant designs were based on the use of high temperature regenerative air preheaters separately fired by a low Btu gas produced from a coal gasifier which was integrated with the power plant. The third reference plant design was based on the use of oxygen enriched combustion air preheated to a more moderate temperature in a tubular type metallic recuperative heat exchanger which is part of the bottoming plant heat recovery system. Comparative information was developed on plant performance and economics. The highest net plant efficiency of about 45 percent was attained by the reference plant design with the use of a high temperature air preheater separately fired with the advanced entrained bed gasifier. The use of oxygen enrichment of the combustion air yielded the lowest cost of generating electricity at a slightly lower plant efficiency. Both of these two reference plant designs are identified as potentially attractive for early MHD power plant applications. R.E.S.

79A37907 ISSUE 15 PAGE 2794 CATEGORY 44  
79/00/00 4 PAGES UNCLASSIFIED DOCUMENT

UTIT: Prospects of MHD power generation in India using coal  
AUTH: A/RADHAPRASAD, V. R.; R. MALGHAN, V. R.; C/RAVI KUMAR, K. FAA: C/Dharat Heavy Electricals, Ltd., Madras, India)  
In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979. Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 359-361.  
MAJS: /COAL GASIFICATION/ INDIA/ MAGNETOHYDRODYNAMIC GENERATORS/ PROJECT MANAGEMENT  
MINS: /COAL UTILIZATION, ENERGY CONVERSION/ ENERGY TECHNOLOGY/ FLAME TEMPERATURE/ INDUSTRIAL PLANTS/ PLASMA DYNAMICS/ POWER EFFICIENCY/ SPECIFIC HEAT/ SYSTEMS ENGINEERING

ABA: B. J.

ABS: The paper briefly reviews the Indian coal-based MHD power generation program. Program planning includes studies of plasma properties and plasma dynamics; development and testing of high temperature materials; testing of MHD components and subsystems; and investigation of the technical and economic aspects of MHD power cycles.

ABO 18554 # Solar powered liquid metal MHD power systems, E. S. Pierson, G. Faleis, C. R. Reed (Argonne National Laboratory, Argonne, Ill.), and H. Branner (Argonne National Laboratory, Argonne, Ill., Negev, University, BeerSheva, Israel). *American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Dec. 2-7, 1979, Paper 79-WA/Sol 22*, 8 p. 15 refs. Members, \$1.50, nonmembers, \$3.00. Research supported by the Ministry of Energy of Israel, Contract No. W 31-109-eng 38.

The two phase liquid metal MHD power cycles coupled to solar collectors have potentially a higher efficiency of converting solar energy input into useful electrical power output for all collector temperatures. The MHD interaction is a volume effect, so that efficiency is essentially independent of design power level down to fractional megawatt size, and the performance is attractive even at approximately 50 kWe size. The use of two working fluids in the energy conversion system is advantageous in coupling the conversion cycle to solar collectors and direct contact boilers can be used to obtain higher conversion system temperatures. Two liquid metal MHD systems of interest for solar collectors are presented and explained. Liquid metal MHD conversion systems appropriate to low, intermediate, and high collector temperatures are described along with initial efficiency and cost results.

[Author]

79N20512# ISSUE 11 PAGE 1449 CATEGORY 44 RPT#:  
FE-2341-B CNT#: EX-76-C-01-2341 78/04/00 392  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Axial field limitations in MHD generators

AUTH: A/UNKEL, W. C.

CORP: Stanford Univ., Calif. AVAIL:NTIS SAP: HC A17/MF  
A01

MAJS: /AXIAL LOADS/ELECTRIC ARCS/ELECTRIC FIELDS/  
MAGNETOHYDRODYNAMIC GENERATORS

MINS: /ELECTRIC CURRENT/ELECTRICAL FAULTS/ELECTRODES/  
HALL EFFECT

ABA: Author

ABS: The results of an investigation of axial field breakdown in nonslagging wall, combustion driven MHD generators are presented. Breakdown was characterized by a rapid decline in axial voltage and a change in the mode of current transport from a relatively diffuse mode to a highly constricted and extremely destructive mode. Cinephotographic records demonstrated that breakdown could be initiated in the plasma or in the interelectrode insulator. Plasma initiated and insulator initiated breakdown resulted only when a threshold voltage was exceeded. For the electrode wall configuration studied, the threshold voltage for plasma initiated breakdown was significantly higher than the threshold voltage for insulator initiated breakdown. Electro-thermal instability was responsible for the behavior observed in the experiments. A computer model was developed to predict the nonbreakdown and incipient breakdown behavior for the interelectrode insulator region for the simplified configuration.

79N20517# ISSUE 11 PAGE 1449 CATEGORY 44 RPT#:  
FE-2524-B CNT#: EF-77-C-01-2524 78/03/00 259  
PAGES UNCLASSIFIED DOCUMENT

UTTL: MHD power generation: Research, development and engineering TLSP: Quarterly Progress Report, Jan. - Mar. 1978

CORP: Montana Energy and MHD Research and Development Inst., Inc., Butte. AVAIL:NTIS SAP: HC A13/MF A01

MAJS: /ELECTRIC GENERATORS/MAGNETOHYDRODYNAMIC GENERATORS  
/REPORTS/RESEARCH AND DEVELOPMENT/TECHNOLOGY  
ASSESSMENT

MINS: /ABSTRACTS/ENVIRONMENT EFFECTS/GRAPHS (CHARTS)/  
MONTANA/PAPERS/SYSTEMS ANALYSIS/SYSTEMS ENGINEERING  
/TABLES (DATA)/TASKS/TECHNOLOGY TRANSFER/  
UNIVERSITIES

ABA: G. Y.

ABS: A special compilation of several task reports under contract to the U. S. Department of Energy is presented. Summarizing the work accomplished from January to March 1978, the reports cover the MERDI (Montana Energy and MHD Research and Development Institute) Materials Evaluation task and the tasks being performed by the Montana College of Mineral Science and Technology and Montana State University.

79A10136 ISSUE 1 PAGE 115 CATEGORY 44 78/00/00  
7 PAGES UNCLASSIFIED DOCUMENT

UTTL: Considerations for MHD power generation development

AUTH: A/SHANKLIN, R. V. PAA: A/(U.S. Department of Energy,  
Div. of Magnetohydrodynamics, Washington, D.C.)  
In: Intersociety Energy Conversion Engineering  
Conference, 13th, San Diego, Calif., August 20-25,  
1978, Proceedings, Volume 2. (A79-10001 01-44)  
Warrendale, Pa., Society of Automotive Engineers,  
Inc., 1978, p. 1242-1248.

MAJS: /ECONOMIC ANALYSIS/ELECTRIC POWER PLANTS/ENERGY  
CONVERSION EFFICIENCY/MAGNETOHYDRODYNAMIC GENERATORS  
/STEAM TURBINES

MINS: /COAL UTILIZATION/COST EFFECTIVENESS/ENERGY  
TECHNOLOGY/ENVIRONMENT PROTECTION/POLLUTION CONTROL/  
TECHNOLOGICAL FORECASTING/THERMAL POLLUTION

ABA: G.R.

ABS: Magnetohydrodynamic generation (MHD) is a method of direct electromechanical power conversion based on the interaction of conducting fluids with magnetic fields. The Energy Conversion Alternative Study which included a comparative economic analysis of several advanced electric power system concepts completed during 1975-76 shows that MHD is economically viable. The characteristics of an open cycle MHD/steam system are considered along with questions regarding the historical development of the concept of MHD power generation. A new chapter in the history of the national program was opened in September 1975 with the formation of the MHD Division of DOE (then ERDA). The overall objective of the MHD program is the demonstration in the 1990's of an electrical, utility-sized MHD/steam power plant, utilizing coal as fuel in a process that is economically attractive and environmentally acceptable. Accomplishments in critical areas are discussed.

79A33426# ISSUE 13 PAGE 2362 CATEGORY 33  
78/00/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Developments in electrodes and power conditioning systems for open-cycle MHD generators

AUTH: A/ZAUDERER, B.; B/COPPA, A. P.; C/NOONE, M. J.;  
D/DEDOMINICIS, L.; E/GATTI, A.; F/ROGERS, D. A.;  
G/FEINGOLD, E.; H/FAUST, B. PAA: H/General  
Electric Co., King of Prussia, Pa.)  
In: Symposium on the Engineering Aspects of  
Magnetohydrodynamics, 17th, Stanford, Calif., March  
27-29, 1978, Proceedings. (A79-33379 13-31) Stanford,  
Calif., Stanford University, 1978, p. 1.2.1-1.2.8.

MAJS: /MAGNETOHYDRODYNAMIC GENERATORS/PERFORMANCE TESTS/  
PLASMA ELECTRODES/POWER CONDITIONING

MINS: /CERAMICS/CYCLES/ENERGY TECHNOLOGY/FABRICATION/  
HEAT TRANSFER/PRODUCT DEVELOPMENT/REFRACTORY  
MATERIALS/REFRACTORY METAL ALLOYS/THERMAL  
CONDUCTIVITY



TP Advances in cryogenic engineering. v.23 /  
 1990 edited by K. D. Timmerhaus. -- New York :  
 .A3 Plenum Press, 1978.  
 v.23 xviii, 747 p. : ill.

# Superconductivity Applications—MHD Magnets

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 ENTHALPY EXTRACTION OF MHD-GENERATORS, by  
 J. Batenburg and A. Veeffkind  
 Energy Conversion, vol. 18, no. 1, 1978, p. 9

79N26546# ISSUE 17 PAGE 2286 CATEGORY 45 RPT#:  
 CONF-781109-18 CNT# W-31-109-ENG-38 78/11/28 22  
 PAGES UNCLASSIFIED DOCUMENT

- UTTL: Control of sulfur dioxide and particulate emission in  
 MHD power systems using high sulfur coal  
 AUTH: A/TEMPELMAYER, K. E.; B/BLACKBURN, P.; C/SI-TINO, A.  
 : D/HOPENFELD, J.; E/SPURGEON, W. PAA: E/Gilbert  
 Associates)  
 CORP: Argonne National Lab., Ill. AVAIL NTIS SAP: MC  
 AC2/MF A01  
 Presented at Environ. Control Symp., Washington, D.  
 C., 28-30 Nov. 1978  
 MAJS: /\*EMISSION/\*MAGNETOHYDRODYNAMIC GENERATORS/\*POLLUTION  
 CONTROL/\*SULFUR DIOXIDES  
 MINS: / COAL/ NITROGEN OXIDES/ PARTICLES  
 ABA: DOE  
 ABS: The only air pollutant emission standards existing  
 today are for SO<sub>2</sub>, NO/sub x/ and particulate matter.  
 There is a high probability that MHD systems will be  
 able to achieve not only the present-day emission  
 limits for the substances but will also be able to  
 comply with anticipated future emission levels of  
 SO/sub x/ and NO/sub x/. The built in processes for  
 the control of SO/sub x/ and NO/sub x/ are described  
 briefly. Particulate emissions in an MHD system will  
 be small submicron particulate flyash particles coated  
 with potassium sulfate, as well as potassium sulfate  
 particles. Electrostatic precipitators and  
 conventional baghouses may provide the means for  
 collection of solid particulates. There is no reason  
 to believe that the control of toxic carcinogenic and  
 heavy metal emissions for MHD systems will represent a  
 problem, either in effectiveness, cost, or convenience  
 which is unique to MHD system.

79A16491# ISSUE 4 PAGE 571 CATEGORY 27  
 78/00/00 87 PAGES UNCLASSIFIED DOCUMENT

- UTTL: Materials --- for high temperature MHD technology  
 AUTH: A/SCHNEIDER, S. J.; B/FREDERIKSE, H. P. R.;  
 C/TELEGIN, G. P.; D/ROMANOV, A. I.  
 In: Open-cycle magnetohydrodynamic electrical power  
 generation. (A79-16478 04-75) Argonne, Ill., Argonne  
 National Laboratory; Moscow, Izdatel'stvo Nauka, 1978.  
 p. 535-521.  
 MAJS: /\*ENERGY TECHNOLOGY/\*HIGH TEMPERATURE RESEARCH/\*  
 MAGNETOHYDRODYNAMIC GENERATORS/\*REFRACTORY MATERIALS  
 MINS: / BOILERS/ ELECTRODES/ HEATING EQUIPMENT/ INSULATORS/  
 STEAM FLOW/ WORKING FLUIDS  
 ABA: S.D.  
 ABS: The paper outlines the present status of materials  
 development in MHD through discussions of the scope  
 and nature of the relevant problems, definition of  
 materials selection criteria and candidate materials,  
 along with description of materials performance under  
 actual or near-actual MHD conditions. Present  
 evaluation of the most promising materials are  
 summarized for MHD generators, cold electrodes,  
 insulators, preheater, combustor, and steam generator.  
 Test results from the Soviet U-02 and U-25  
 installations are also presented.

TP  
480  
.A6  
v.7

Applications of cryogenic technology, v. 7 /  
edited by James P. Missig, Robert W. Vance.  
-- Flushine, N.Y. : Scholium International,  
c1978.

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79A16483# ISSUE 4 PAGE 664 CATEGORY 45  
78/00/00 30 PAGES UNCLASSIFIED DOCUMENT

UTTL: Protection of the biosphere --- MHD power stations  
pollution reduction

AUTH: A/BIENSTOCK, D.; E/MASLENNIKOV, V. M.  
In: Open-cycle magnetohydrodynamic electrical power  
generation. (A79-16478 (4-75) Argonne, Ill., Argonne  
National Laboratory; Moscow, Izdatel'stvo Nauka, 1978.  
p. 127-156.

MAJS: /\*BIOSPHERE/\*ELECTRIC POWER PLANTS/\*ENVIRONMENT  
PROTECTION/\*MAGNETHYDRODYNAMIC GENERATORS/\*POLLUTION  
CONTROL

MINS: / AIR POLLUTION/ ENERGY TECHNOLOGY/ THERMAL POLLUTION/  
WASTE UTILIZATION

ABA: S.D.

ABS: The study shows how MHD power stations can  
substantially reduce pollutant emissions (sulfur  
oxides, nitrogen oxides) and meet the environmental  
clean air and thermal pollution standards. Moreover,  
the existing technology is capable of achieving  
adequate removal of particulate impurities from flue  
gases. Technical-economic analysis indicates that  
electricity from an MHD power station can be made  
10-15% less expensive through production of nitric  
acid from NOx taken from the stack.

THE PHYSICS OF MHD GENERATORS

Soviet Physics USPEKHI, vol. 123, no. 2, October 1977  
p. 861-869

A brief popular review is presented of physical phenomena in MHD plasma generators of electric power. The interaction between a current of weakly ionized gas and a transverse magnetic field is described. Qualitative explanations are given of the leading instabilities of this current and of certain phenomena near the electrodes. The characteristic properties of the plasma in MHD generators with nonequilibrium conductivity are noted. They include ionization turbulence, motion of the ionization front through a weakly ionized gas, and its stabilization at entry into the MHD duct. Data characterizing the scientific and technological achievements in the development of MHD generators are cited.



COLD WALL FARADAY TYPE GENERATING CHANNEL  
Yoshitomo Kusaka, Toshihisa Masuda, Shigeru Ikeda and  
Takeo Honda  
Energy Conversion  
Vol. 17 no. 1 1977  
p.7-18

TWO DIMENSIONAL ANALYSIS OF END EFFECTS IN  
DIAGONAL TYPE MHD GENERATOR.  
M. Ishikawa & J. Umoto  
Energy Conversion, Vol. 17, No. 2/3, 1977,  
p. 113-118.

**Abstract**—Effects of two factors associated with end regions in diagonal type MHD generators, arrangement of output electrodes and attenuation of applied magnetic induction, are investigated by a two-dimensional analysis, showing that a suitable design of end regions can almost extinguish the current concentration at output electrode edges, the eddy current and the potential difference between the adjacent electrodes in end regions.

78A11070 ISSUE 1 PAGE 58 CATEGORY 44 CNT#:  
E(49-18)-1811 77/00/00 9 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Dynamic modeling and control of  
magnetohydrodynamic/steam systems  
AUTH: A/ASPINES, J.; B/PIERRE, D. A. PAA: A/(New  
Hampshire, University, Durham, N.H.); B/(Montana  
State University, Bozeman, Mont.)  
In: Energy development III. (A78-11069 01-44) New  
York, Institute of Electrical and Electronics  
Engineers, Inc., 1977, p. 7-15.  
MAJS: /\*COMPUTERIZED SIMULATION/\*DYNAMIC CONTROL/\*ELECTRIC  
POWER PLANTS/\*MAGNETOHYDRODYNAMIC GENERATORS/\*OPTIMAL  
CONTROL/\*STEAM TURBINES  
MINS: / CONTROL SIMULATION/ DYNAMIC MODELS/ ENERGY  
TECHNOLOGY/ FEEDBACK CONTROL/ SYSTEM EFFECTIVENESS/  
SYSTEMS ENGINEERING/ TIME RESPONSE  
ABA: (Author)  
ABS: Dynamic characteristics of magnetohydrodynamic  
(MHD)/steam electrical power generating plants are  
investigated, as are control requirements for  
desirable system response. A dynamic computer model of  
the MHD/steam combined cycle is developed.  
Representative computer simulation results showing the  
effects of various control configurations are given,  
including a quasi-optimized response based on  
minimizing integral-square error of actual system  
output compared with desired output.

77A41557# ISSUE 19 PAGE 3302 CATEGORY 75 RPT#:  
AIAA 77-1010 77/00/00 8 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Utility views of MHD power generation  
AUTH: A/SHIH, C. H.; B/GUHA, M. K. PAA: B/(American  
Electric Power Service Corp., New York, N.Y.)  
In: New options in energy technology; Proceedings of  
the Conference, San Francisco, Calif., August 2-4,  
1977. (A77-41551 19-44) New York, American Institute  
of Aeronautics and Astronautics, Inc., 1977, p. 33-40.  
MAJS: /\*COST EFFECTIVENESS/\*ECOLOGY/\*ELECTRIC POWER PLANTS/\*  
ENVIRONMENT PROTECTION/\*MAGNETOHYDRODYNAMIC GENERATORS  
/\*POLLUTION CONTROL  
MINS: / COAL UTILIZATION/ COST REDUCTION/ DOMESTIC ENERGY/  
ECONOMIC ANALYSIS/ ENERGY TECHNOLOGY/ FUEL CONSUMPTION  
ABA: R.D.V.  
ABS: Economic and ecological advantages of developing an  
open-cycle MHD process for generating electric power  
from MHD combustion of coal, without the use of  
turbines, rotating generators, or other moving parts  
absorbing energy, are discussed and listed explicitly.  
Higher efficiencies, low cost of electric power  
generated, far more manageable pollution problems, 50%  
less warm water effluents, inertialess startup and  
shutdown, reduced maintenance costs, and ability to  
handle all grades of coal without pretreatment (except  
for moisture removal) are cited as salient advantages.  
Elevated temperatures and use of highly corrosive  
potassium salts are examined for possible  
environmental impact.

77A36381\* ISSUE 16 PAGE 2772 CATEGORY 75 CNT#:  
NAS3-19407 77/06/00 13 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Design of closed-cycle MHD generator with  
nonequilibrium ionization and system  
AUTH: A/VOSHALL, R. E.; B/WRIGHT, R. J.; C/LIEBERMANN, R.  
W. PAA: C/(Westinghouse Research Laboratories,  
Pittsburgh, Pa.)  
CORP: Westinghouse Research Labs., Pittsburgh, Pa.  
IEEE Transactions on Plasma Science, vol. PS-5, June  
1977, p. 110-112.  
MAJS: /\*CLOSED CYCLES/\*ELECTRIC POWER PLANTS/\*GAS IONIZATION  
/\*MAGNETOHYDRODYNAMIC GENERATORS/\*NONEQUILIBRIUM  
IONIZATION/\*THERMODYNAMIC EFFICIENCY  
MINS: / COMPUTER PROGRAMS/ ELECTRIC POTENTIAL/  
ELECTROCONDUCTIVITY/ POWER GAIN/ TABLES (DATA)/  
WORKING FLUIDS  
ABA: B.J.  
ABS: A method is developed to include the nonequilibrium  
ionization process in the MHD generator duct design  
equations, and these equations are coupled to the  
thermodynamic conditions of the closed cycle system.  
This is used to relate MHD generator size,  
configuration and gas conditions to the overall  
thermodynamic efficiency of the system. The system  
studied consists of an MHD loop (Ar + Cs or He + Cs)  
topping a steam bottoming plant.

77A39543# ISSUE 18 PAGE 3104 CATEGORY 75  
77/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Design and performance of high temperature ceramic  
electrode modules --- in MHD generators

AUTH: A/BOWEN, H. K.; B/POBER, R. L.; C/CORDERO, J.;  
D/YOSHIMURA, M.; E/NASH-WEBBER, J. L.; F/LOUIS, J.  
F.; G/CANNON, W. R. PAA: G/(MIT, Cambridge, Mass.)  
In: Symposium on the Engineering Aspects of  
Magnetohydrodynamics, 16th, Pittsburgh, Pa., May  
16-18, 1977. Proceedings. (A77-39526 18-75)  
Pittsburgh, Pa., Energy Research and Development  
Administration, 1977. p. IV.6.35-IV.6-40.  
ERDA-supported research.

MAJS: /\*CERAMICS/\*MAGNETOHYDRODYNAMIC GENERATORS/\*PLASMA  
ELECTRODES/\*REFRACTORY MATERIALS

MINS: / DESIGN ANALYSIS/ ELECTROCHEMISTRY/ HIGH TEMPERATURE  
RESEARCH

ABA: (Author)

ABS: The advantages of super-hot wall electrodes in MHD  
generators are numerous, but the design, fabrication,  
and materials of construction have not been  
established. New materials and new module designs were  
studied. Electrode modules were tested in a variety of  
configurations, e.g., singly, in pairs and with or  
without guard electrodes. Failure of one electrode in  
a stack affects the performance of the other  
electrodes. The cool boundary layer from an upstream  
cold wall can give rise to preferential current paths  
and arcing. Current fluctuations across the plasma  
seemed to be directly related to electrode surface  
conditions, among other reasons. Single and multilayer  
ceramic electrodes were fabricated. Failures were  
principally due to electrochemical effects at  
interfaces between partial ionic conductors with  
electronic conductors. Extensive laboratory tests were  
performed on the compatibility, fluxing and melting  
points of these materials.

78N30673# ISSUE 21 PAGE 2838 CATEGORY 44 RPT#:  
CONF-771102-20 CNT#: W-31-109-ENG-38 77/00/00 27  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Prospects for open-cycle MHD plants

AUTH: A/PETRICK, M.; B/REDMAN, W. C.

CORP: Argonne National Lab., Ill. AVAIL:NTIS SAP: HC  
A03/MF A01

Presented at the Am. Inst. of Chem. Engr. Symp. on  
Alternate Processes for Clean Generation of Electric  
Power from Coal, New York, 16 Nov. 1977

MAJS: /\*ENVIRONMENTAL MONITORING/\*MAGNETOHYDRODYNAMIC  
GENERATORS

MINS: / ECONOMICS/ ENVIRONMENTAL SURVEYS

ABA: ERA

ABS: Technical problems to be solved and economic promise  
vis-a-vis other advanced systems for electrical power  
generation are assessed. The bases for a reduced  
environmental impact are explained. Ongoing programs  
for the development of coal-fired plants are reviewed.

77A39552# ISSUE 18 PAGE 3105 CATEGORY 75 CNT#:  
E(49-18)-2341 77/00/00 7 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Axial field limitations in MHD generators

AUTH: A/UNKEL, W.; B/KRUGER, C. H. PAA: B/(Stanford  
University, Stanford, Calif.)

In: Symposium on the Engineering Aspects of  
Magnetohydrodynamics, 16th, Pittsburgh, Pa., May  
16-18, 1977. Proceedings. (A77-39526 18-75)  
Pittsburgh, Pa., Energy Research and Development  
Administration, 1977. p. VI.4.14-VI.4.20.

MAJS: /\*ELECTRIC FIELDS/\*ELECTRICAL FAULTS/\*  
MAGNETOHYDRODYNAMIC GENERATORS/\*VOLT-AMPERE  
CHARACTERISTICS

MINS: / CATHODES/ ELECTRIC CURRENT/ ELECTRODES/ HALL EFFECT/  
INSULATORS/ PHOTOGRAPHIC RECORDING/ PLASMA DIAGNOSTICS

ABA: (Author)

ABS: Induced and applied field experiments and theoretical  
calculations have been performed to aid in the  
understanding of Hall voltage breakdown. Insulator  
dominated breakdown was observed in the induced field  
experiments and was qualitatively similar to insulator  
dominated breakdown observed in the applied field  
experiments. The breakdown threshold voltage for  
insulator dominated breakdown was somewhat lower than  
for the same gap in applied field experiments. Further  
applied field experiments confirmed the distinction  
between plasma and insulator dominated breakdown and  
showed that for plasma breakdown, the insulator  
eventually becomes the dominant current carrier. This  
implies that modeling of post-breakdown behavior  
should concentrate on insulator conduction rather than  
on plasma conduction. Comparison of theory and  
experiment for the applied field configuration  
indicate that the threshold for two-dimensional plasma  
and insulator thermal runaway can be taken as an upper  
bound for the experimentally observed plasma and  
insulator dominated breakdown respectively.

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1977

International Magnetism Conferences, Los  
Angeles, 1977.

Digests of the Intermag Conferences...  
c1977.  
Engineers.

"77CH1242-7TAG."

1. Magnetism--Congresses. 2. Magnetic  
devices--Congresses. I. Institute of

31-5. A LARGE CONVENTIONAL MHD MAGNET  
J.M. Tarrh  
Magnetic Engineering Associates,  
Inc.  
Cambridge, Massachusetts

77A39563# ISSUE 18 PAGE 3107 CATEGORY 75

77/00/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Some properties of coal slags of importance to MHD  
AUTH: A/CAPPS, W. PAA: A/(National Bureau of Standards,  
Washington, D.C.)

In: Symposium on the Engineering Aspects of  
Magnetohydrodynamics, 16th, Pittsburgh, Pa., May  
16-18, 1977, Proceedings. (A77-39526 18-75)  
Pittsburgh, Pa., Energy Research and Development  
Administration, 1977, p. VIII.3.21-VIII.3.25.  
Research supported by the U.S. Department of the  
Interior and ERDA.

MAJS: /\*CHEMICAL PROPERTIES/\*COAL/\*ELECTROCONDUCTIVITY/\*  
MAGNETOHYDRODYNAMIC GENERATORS/\*SLAGS/\*THERMAL  
DIFFUSIVITY

MINS: / CHEMICAL ANALYSIS/ COMBUSTION PRODUCTS/ POTASSIUM  
OXIDES/ TEMPERATURE EFFECTS/ VISCOSITY

ABA: (Author)

ABS: Coal slag viscosity, thermal diffusivity, electrical  
conductivity, vaporization effects and seed-slag  
interactions are briefly described as they relate to  
MHD problems. Equations relate viscosity to  
composition and temperature. K2O from seed causes an  
increase in viscosity below 30% and a decrease in  
greater amounts. The maximum is at 15 to 20% K2O. Data  
on several real slags are given. Slag liquidus  
temperatures can be inferred from viscosity data.  
Thermal diffusivity of real and synthetic slags show a  
minimum at 1000-1100 C. K2O and SiO2 lower  
diffusivity; Fe2O3 raises it. Vaporization data have  
been used to predict a stable slag in the channel area  
with negligible fractionation. Phase equilibria data  
indicate potassium aluminosilicates will remain  
stable in K2O-rich vapors but will crystallize in  
iron-rich slags. This will affect viscosity and  
conductivity.

78N21662# ISSUE 12 PAGE 1604 CATEGORY 44 RPT#:  
AE01-26 NRC-76-20 76/02/00 19 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Study of some recent advances in the concept and  
design of MHD generators

AUTH: A/VAKILIAN, M.

CORP: Atomic Energy Organization of Iran, Teheran. CSS: (I  
Reactor Technology Section.) AVAIL: NTIS SAP: (US  
Sales Only) HC A02/MF A01; ERDA Depository Libraries

MAJS: /\*ENERGY CONVERSION/\*MAGNETOHYDRODYNAMIC GENERATORS

MINS: / ENVIRONMENT EFFECTS/ HIGH TEMPERATURE/ POWER PLANTS

ABA: ERA

ABS: Direct conversion of energy using a high temperature  
working fluid makes magnetohydrodynamics (MHD) power  
plants potentially much more efficient than steam  
power stations. The study indicated an overall  
efficiency of 50 percent to 60 percent. This compared  
with most modern fossil-fuel plants at 40 percent  
efficiency. Advances in design and construction of  
experimental and commercial MHD plants developed in  
various countries are presented. Environmental effects  
and advantages of the MHD power plants over the more  
conventional fossil and nuclear plants are discussed.

77A39572# ISSUE 18 PAGE 3107 CATEGORY 75 CNT#:  
E(49-19)-1811 77/00/00 7 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Dynamic modeling and control of  
magnetohydrodynamic/steam electrical power generating  
plants

AUTH: A/ASPINES, J. D.; B/PIERRE, D. A. PAA: A/(New  
Hampshire, University, Durham, N.H.); B/(Montana  
State University, Bozeman, Mont.)

In: Symposium on the Engineering Aspects of  
Magnetohydrodynamics, 16th, Pittsburgh, Pa., May  
16-18, 1977, Proceedings. (A77-39526 18-75)  
Pittsburgh, Pa., Energy Research and Development  
Administration, 1977, p. X.1.1-X.1.7. Research  
supported by the Montana Energy and MHD Research and  
Development Institute.

MAJS: /\*DYNAMIC CONTROL/\*ELECTRIC POWER PLANTS/\*  
MAGNETOHYDRODYNAMIC GENERATORS/\*STEAM TURBINE

MINS: / DYNAMIC MODELS/ ENERGY TECHNOLOGY/ TURBOGENERATORS

ABA: (Author)

ABS: A dynamic power-flow simulation of an overall  
magnetohydrodynamic (MHD)/steam electrical power  
generating plant is developed. Several control  
configurations are applied to the system, and their  
effects on system dynamic response are presented. The  
overall combined-cycle system model utilizes an  
input-output characterization of the  
combustor/nozzle/channel/diffuser. This  
characterization is developed from polynomial  
approximations of data resulting from the solutions of  
energy balance, state and continuity equations for the  
combustor and the quasi one-dimensional MHD equations  
for the nozzle, channel, and diffuser. The boiler and  
turbine valve model has turbine valve area and power  
available to generate steam as inputs, and throttle  
pressure, power to the turbines, and boiler and stack  
losses as outputs. Regenerative air preheater cycling  
is also modeled, and the effect of cycling on plant  
output is given.



78A10745 ISSUE 1 PAGE 107 CATEGORY 75 76/00/00  
8 PAGES UNCLASSIFIED DOCUMENT

UTTL: National program for MHD power generation  
AUTH: A/JACKSON, W. D.; B/SHANKLIN, R. V.; C/ZYGIELBAUM,  
P. S. PAA: B/(ERDA, Washington, D.C.); C/(Electric  
Power Research Institute, Palo Alto, Calif.)  
In: Energy development II. (A78-10729 01-44) New York,  
Institute of Electrical and Electronics Engineers,  
Inc., 1976, p. 158-165.

MAJS: /\*COAL UTILIZATION/\*ELECTRIC POWER/\*  
MAGNETOHYDRODYNAMIC GENERATORS/\*RESEARCH AND  
DEVELOPMENT/\*TECHNOLOGY ASSESSMENT

MINS: / COMBUSTION CHAMBERS/ ELECTRODES/ ENERGY TECHNOLOGY/  
OPERATIONAL PROBLEMS/ REFRACTORY MATERIALS/ SLAGS

ABA: J.M.B.

ABS: Development of MHD power generation systems in the  
U.S. is reviewed, with attention given to testing of  
MHD channels and electrodes, the use of  
high-temperature corrosion/erosion resistant materials  
for MHD components, and the Engineering Test Facility  
to be built under ERDA sponsorship in Montana. The  
current emphasis of the U.S. program is on the  
generation of electric power through utilization of  
domestic coal, including high-sulfur content coal;  
demonstrations of coal slag as a protective coating  
for MHD channel walls are reported. Problems related  
to the rate of thermal energy input recovery, turbine  
efficiency, recycling of the potassium seed, and  
emission control are also mentioned. A timetable for  
the development of commercial electric power  
generation by MHD open cycle coal-fired combined cycle  
plants is given.

78N25570# ISSUE 16 PAGE 2139 CATEGORY 44 RPT#:  
R-2128-ERDA CNT#: EX-76-C-01-2261 77/08/00 94  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Noble-gas closed-cycle system of magnetohydrodynamic  
power generation

AUTH: A/PRI, R. Y.; B/HESS, R. W.

CORP: RAND Corp., Santa Monica, Calif. AVAIL:NTIS SAP:  
HC A05/MF A01

ABA: ERA

ABS: The critical components of the closed cycle system,  
like those of the open cycle system, are the coal  
combustor, heat exchanger, MHD generator, seed  
recovery system, and power conditioning equipment.  
Although the components may be common, the  
technologies pacing the development of the two systems  
differ substantially. The current concept for the  
design of a closed cycle system calls for a  
regenerative heat exchanger in which the same  
refractory surface will come in contact with both the  
combustion gases and the working fluid. The heat  
exchanger must be designed to ensure a low enough  
level of contamination carry over and leakage to  
maintain the noble gas loop. The same type of heat  
exchanger used as the air preheater in an open cycle  
system presumably could tolerate greater leakage and  
contamination.

77A48571# ISSUE 23 PAGE 4066 CATEGORY 75  
77/10/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: MHD power generation with fully ionized seed  
AUTH: A/YAMASAKI, H.; B/SHIODA, S. PAA: B/(Tokyo  
Institute of Technology, Tokyo, Japan)  
Journal of Energy, vol. 1, Sept.-Oct. 1977, p.  
301-305.

MAJS: /\*ARGON PLASMA/\*GAS IONIZATION/\*HALL GENERATORS/\*  
MAGNETOHYDRODYNAMIC GENERATORS/\*MAGNETOHYDRODYNAMIC  
STABILITY

MINS: / ELECTRON DENSITY (CONCENTRATION)/ HALL EFFECT/  
MAGNETIC FLUX/ PLASMA JETS/ POTASSIUM/ RADIANT FLUX  
DENSITY/ VOLT-AMPERE CHARACTERISTICS

ABA: (Author)

ABS: Recovery of power density in the regime of fully  
ionized seed has been demonstrated experimentally  
using an MHD disk generator with the effective hall  
parameter up to 5.0 when the seed was fully ionized.  
The experiments were conducted with a shock-heated and  
potassium-seeded argon plasma under the following  
conditions: stagnation gas pressure = 0.92 atm,  
stagnation gas temperature = 2750 K, flow Mach number  
= 2.5, and seed fraction = 1.4 x 10 to the -5th.  
Measurements of electron-number density and  
spectroscopic observations of both potassium and argon  
lines confirmed that the recovery of power output was  
due to the reduction of ionization instability. This  
fact indicates that the successful operation of a disk  
generator utilizing nonequilibrium ionization seems to  
be possible and that the suppression of ionization  
instability can also provide higher adiabatic  
efficiency. Furthermore, the lower seed fraction  
offers technological advantages related to seed  
problems.

78A43176 ISSUE 18 PAGE 3299 CATEGORY 44  
77/04/00 13 PAGES UNCLASSIFIED DOCUMENT

UTTL: Open-cycle MHD energy conversion - Prospects and  
developments for central station power generation

AUTH: A/HALS, F.; B/PETTY, S.; C/STICKLER, D.; D/SOLBES,  
A. PAA: D/(Avco Everett Research Laboratory, Inc.,  
Everett, Mass.)

Illinois Institute of Technology, American Power  
Conference, Chicago, Ill., Apr. 18-20, 1977, Paper, 13  
P.

ABA: M.L.

ABS: The principles of MHD, MHD research projects, and the  
conservational and environmental benefits offered by  
MHD are described. Topics discussed include the MHD  
channel, the superconducting magnet, coal combustion  
for an MHD plant, air preheaters, seed recovery and  
regeneration, and a bottoming plant including NOx  
emission control. It is concluded that significant  
progress has been achieved in the development of  
open-cycle MHD; an experimental MHD generator has been  
tested under conditions which realistically simulate  
those of projected full-scale coal-burning MHD  
generators. The development of a pilot-scale  
engineering test facility is considered.

78A11108 ISSUE 1 PAGE 61 CATEGORY 44 77/00/00  
9 PAGES UNCLASSIFIED DOCUMENT

UTTL: MHD generators for baseload power stations

AUTH: A/RING, L. E.; B/GARRISON, G. W. PAA: B/(ARO, Inc.,  
Arnold Air Force Station, Tenn.)

In: Energy crisis: An evaluation of our resource  
potential; Proceedings of the Third Annual UM-MEC  
Conference on Energy, Rolla, Mo., October 12-14, 1976.  
(A78-11089 01-44) North Hollywood, Calif.: Western  
Periodicals Co., 1977, p. 559-567. ERDA-Sponsored  
research.

MAJS: /\*CLEAN ENERGY/\*COAL UTILIZATION/\*ELECTRIC POWER  
PLANTS/\*ENERGY CONVERSION EFFICIENCY/\*  
MAGNETOHYDRODYNAMIC GENERATORS

MINS: / AIR POLLUTION/ CHANNEL FLOW/ DIFFUSERS/ ENERGY  
TECHNOLOGY/ STEAM TURBINES/ SUPERCONDUCTING MAGNETS/  
SYSTEMS ENGINEERING

ABA: V.P.

ABS: The expected use of coal-fired baseload plants for  
power generation indicates the need for an efficient  
pollution-free system capable of operating on  
high-sulfur coals. In the present paper it is shown  
that an MHD system operating on coal can meet these  
requirements and can provide an overall efficiency of  
conventional steam power plants. The envisaged  
baseload MHD power plant consists of a combustor  
(operating at approximately 5 atm and 2800 K, using  
coal and preheated air); an MHD generator channel  
inside a superconducting magnet; a diffuser; an air  
preheater; and a steam generator, with the steam  
utilized in a conventional steam turbine.

78A17494# ISSUE 5 PAGE 822 CATEGORY 44 RPT#:  
ASME PAPER 77-HT-62 77/08/00 10 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Heat transfer problem associated with an MHD power  
generation system - An overview

AUTH: A/POSTLETHWAITE, A. W.; B/SLUYTER, M. M. PAA:  
B/(ERDA, MHD Div., Washington, D.C.) SAP: MEMBERS,  
\$1.50; NONMEMBERS, \$3.00

American Institute of Chemical Engineers and American  
Society of Mechanical Engineers, Heat Transfer  
Conference, Salt Lake City, Utah, Aug. 15-17, 1977.  
ASME, 10 p.

MAJS: /\*HEAT TRANSFER/\*MAGNETOHYDRODYNAMIC GENERATORS

MINS: / COMBUSTION CHAMBERS/ HEATERS/ HIGH TEMPERATURE AIR/  
PLASMA TEMPERATURE/ TECHNOLOGY ASSESSMENT

ABA: (Author)

ABS: Research in the field of MHD has advanced to the point  
where the development of an operational system is  
feasible. The primary system being considered by ERDA  
is an open-cycle MHD/steam cycle power loop. Critical  
thermal problems impact the system due to hot ionized  
plasma, seed injection, slag deposition and high  
temperature air heaters. MHD power generation has  
entered the development phase and commercial operation  
can be achieved by existing materials and techniques.

78A33146# ISSUE 13 PAGE 2392 CATEGORY 44 RPT#:  
ASME PAPER 77-WA/ENER-8 77/11/00 14 PAGES

UNCLASSIFIED DOCUMENT

UTTL: Coal fired non-equilibrium, Closed Cycle MHD/steam  
power generation

AUTH: A/ZAUDERER, B.; B/MARSTON, C. H.; C/DAVIS, L. K.;  
D/ROGERS, D. A.; E/BAZAN, J.; F/FARSONS, J. PAA:  
D/IGE Space Sciences Laboratory, King of Prussia, Pa.)  
: E/(Foster Wheeler Development Corp., John Blizard  
Research Center, Livingston, N.J.); F/(General  
Electric Co., Schenectady, N.Y.) SAP: MEMBERS,  
\$1.50; NONMEMBERS, \$3.00

American Society of Mechanical Engineers, Winter  
Annual Meeting, Atlanta, Ga., Nov. 27-Dec. 2, 1977,  
14 p. ERDA-supported research.

MAJS: /\*BOILERS/\*CLOSED CYCLES/\*COAL UTILIZATION/\*ELECTRIC  
POWER PLANTS/\*MAGNETOHYDRODYNAMIC GENERATORS/\*  
NONEQUILIBRIUM PLASMAS

MINS: / ARGON/ COMBUSTION CHAMBERS/ COMBUSTION TEMPERATURE/  
COST ESTIMATES/ ENERGY CONVERSION EFFICIENCY/ ENERGY  
TECHNOLOGY/ HEAT EXCHANGERS/ PRESSURIZING/ VOLTAGE  
CONVERTERS (DC TO DC)

ABA: (Author)

ABS: A 1000 Mwe Closed Cycle MHD/steam bottoming power  
plant which incorporates an integrated, two-stage,  
pressurized fluidized bed combustor meeting all  
emission control requirements has been studied. The  
coal pile to bus bar efficiency for this plant is  
calculated to be 46 percent. A dc-dc conversion system  
is proposed for matching the output of the Faraday MHD  
Channel to the inverters. The effect on efficiency of  
perturbations in nominal performance of key components  
is shown, along with regenerative heat exchanger  
performance and plant layout.

78A43406 ISSUE 19 PAGE 3550 CATEGORY 75  
77/00/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: Coal-fired MHD power generation

AUTH: A/KUMNICK, A. J. PAA: A/(Montana State University,  
Bozeman, Mont.)

In: Coal processing technology, Volume 3. (A78-43403  
19-44) New York, American Institute of Chemical  
Engineers, 1977, p. 12-15.

ABA: G.R.

ABS: The first MHD generator, which became a laboratory  
reality in 1959, produced 11.5 kW of electric power.  
The interest in MHD generators is related to their  
potential of converting fossil fuel (particularly  
coal) to electricity at a higher efficiency than  
existing technologies. In an MHD generator of the  
considered type, the metal armatures of a conventional  
turbogenerator are replaced by a very hot conducting  
gas moving at a high velocity perpendicular to a  
magnetic field. In the operation of an open cycle  
coal-fired MHD generator, the gas is combustion gas  
which is obtained by burning pulverized coal with  
preheated air. The electrical conductivity of the gas  
is increased by the addition of a 'seed' material such  
as potassium. Critical problem areas regarding the  
development of a commercially feasible MHD system are  
examined.



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- Intersociety Energy Conversion Engineering Conference, 12th, Washington, 1977.  
Proceedings of the 12th Intersociety Energy Conversion Engineering Conference, Washington, D. C., August 28 through September 2, 1977. — La Grange, Ill. :
- 779154 — Design of the Montana Magnetohydrodynamics Component Development and Integration Facility, W. D. Jackson, ERDA, Washington, D.C. .... 988
- 779155 — A Description of the Direct Coal-Fired MHD Test Facility at the University of Tennessee Space Institute, J. B. Dicks, K. E. Tempelmeyer, J. F. Martin, J. W. Muehlhauser, L. W. Crawford, Y. C. L. Wu, H. P. Markant, Univ. of Tenn. Space Inst., Tullahoma, Tenn. .... 995
- 779156 — Progress in Channel Development for Direct Coal Fired MHD, A. Solbes, S. W. Petty, AVCO Everett Res. Lab. Inc., Everett, Mass. ... 1004
- Comparative Evaluation of Technical and Economic Indices for MHD and Thermionic Toppers for Steam Turbine Facilities, G. N. Morozov, USSR Academy of Science, Moscow, USSR ..... 1733
- QC  
809  
.M3  
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1976
- Symposium on the Engineering Aspects of Magnetohydrodynamics, 15th, Philadelphia, 1976.  
Proceedings; [preprint volume] the University of Pennsylvania, Philadelphia, Pennsylvania, May 24-26, 1976. — [s.l. : s.n., 1976?]  
1 v. in various pagings : ill.  
1. Magnetohydrodynamics—Congresses. I.  
Title: Engineering aspects of magnetohydrodynamics. 538.608

## ELECTROHYDRODYNAMIC GENERATORS

79A51999# ISSUE 23 PAGE 4428 CATEGORY 75  
79/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Performance characteristics of a type of electrohydrodynamic generator

AUTH: A/GAWAIN, T. H.; B/BIBLARZ, O. PAA: B/(U.S. Naval Postgraduate School, Monterey, Calif.)

In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979. Proceedings, Volume 2. (A79-51726 23-44) Washington, D.C.: American Chemical Society 1979, p. 1962-1967.

MAJS: /\*ELECTRIC GENERATORS/\*ELECTROHYDRODYNAMICS/\*ENERGY STORAGE/\*MATHEMATICAL MODELS/\*PERFORMANCE PREDICTION/\*WATER VAPOR

MINS: / ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY/ FLUID DYNAMICS/ FLYWHEELS/ GRAPHS (CHARTS)/ TABLES (DATA)

ABA: (Author)

ABS: An electrohydrodynamic power generator which employs an ejector and a so-called 'fluid flywheel' is analyzed. The medium is steam containing charged water droplets. Account is taken of the empirical fact that the maximum electrical field strength that can be sustained is proportional to the fluid density. It is shown, therefore, that the electrical output can be maximized by designing the primary jet for an exit Mach number of 0.71. Estimates are made of the pump work required, of mixing losses in the ejector and of friction and secondary flow losses. Key dimensionless parameters that govern performance are clearly identified. Overall performance of the system is estimated and, unfortunately, pessimistic results are obtained. They indicate that even at 100 atmospheres, the power output is so limited that it is probably insufficient to cover the demand for pump power and to overcome the various losses involved. A hopeful note is that the analysis so clearly pinpoints the problem that it might suggest the means for surmounting it.

78A49949 ISSUE 22 PAGE 4034 CATEGORY 44 CNT#: EY-76-S-02-4130 78/00/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Research in the electrofluid dynamic /EFD/ wind driven generator

AUTH: A/MINARDI, J. E.; B/LAWSON, M. O. PAA: B/(Dayton, University, Dayton, Ohio)

In: NAECON '78; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 16-18, 1978. Volume 2. (A78-49851 22-04) New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 869-873.

MAJS: /\*COLLOIDS/\*ELECTRIC GENERATORS/\*ELECTROHYDRODYNAMICS/\*ENERGY CONVERSION EFFICIENCY/\*WINDPOWERED GENERATORS

MINS: / CHARGED PARTICLES/ CURRENT DENSITY/ ECONOMIC FACTORS / ELECTRIC CURRENT/ ELECTRIC POTENTIAL/ ELECTRODES/ ENERGY TECHNOLOGY/ FEEDBACK CONTROL/ WIND VELOCITY

ABA: (Author)

ABS: The Electrofluid Dynamic (EFD) wind driven generator directly converts wind energy to electrical energy without moving parts. Conventional wind turbines are currently limited in size, with the greatest diameter presently envisaged being 300 to 400 feet. For the EFD wind driven generator there are no fundamental reasons to restrict the size; therefore, economics of scale and far larger powers than conventional systems can be realized. Analyses predict favorable performance characteristics for EFD wind generators; however, specific experimental data have been lacking. Research areas presently being emphasized are discussed and performance of experimental arrays being conducted in an Eiffel-type wind tunnel are also discussed.

78A40362 ISSUE 17 PAGE 3120 CATEGORY 44 CNT#:  
E(11-1)-4130 77/00/00 11 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Electrofluid dynamic /EFD/ wind driven generator  
research

AUTH: A/MINARDI, J. E.; B/LAWSON, M. O. PAA: B/(Dayton,  
University, Dayton, Ohio)

In: Recent advances in engineering science;  
Proceedings of the Fourteenth Annual Meeting,  
Bethlehem, Pa., November 14-16, 1977. (A78-40301  
17-31) Bethlehem, Pa., Lehigh University, 1977. p.  
1237-1247.

MAJS: /\*AERODYNAMIC CHARACTERISTICS/\*ELECTROHYDRODYNAMICS/\*  
ENERGY CONVERSION EFFICIENCY/\*WINDPOWERED GENERATORS

MINS: / AERODYNAMIC DRAG/ AEROSOLS/ ENERGY TECHNOLOGY/  
VOLT-AMPERE CHARACTERISTICS/ WINDPOWER UTILIZATION

ABA: G.R.

ABS: The theory of electrofluid dynamic (EFD) wind  
generators is based on an intimate combination of  
aerodynamic and electrical considerations. It has been  
shown by Minardi (1966) that a successful EFD  
generator must use colloid particles to achieve  
reasonable efficiencies. The basic equations of the  
theory constitute a combination of the relations of  
the ideal wind converter theory provided by Betz  
(1927) and the one-dimensional EFD theory developed by  
Lawson et al. (1961) for charged particles. The  
performance of the EFD wind generator as a function of  
mobility is shown in a graph. The performance  
characteristics for an EFD wind driven generator made  
of 1 ft tubes are also presented and attention is  
given to a computer study of suitable EFD wind  
generator configurations.

77N24623# ISSUE 15 PAGE 2014 CATEGORY 44 RPT#:  
AD-A033729 AFAPL-TR-76-31 CNT#: F33615-75-C-4085  
76/07/00 116 PAGES UNCLASSIFIED DOCUMENT

UTTL: Study on electrofluid dynamic power generation TLSP:  
Final Technical Report, 23 Apr. 1973 - 23 Jan. 1976

AUTH: A/HUBBERMAN, M. N.; B/SHELTON, H.; C/KRIEVE, W.;  
D/DAILEY, C. L.

CORP: TRW Defense and Space Systems Group, Redondo Beach,  
Calif. CSS: (Propulsion and Combustion System Dept.)  
AVAIL NTIS SAP: HC A06/MF A01  
Wright-Patterson AFB, Ohio AFAPL

ABA: Author (GRA)

ABS: A three-year program to develop and advance  
Electrofluid Dynamic (EFD) Power Generation technology  
is described. A range of axisymmetric EFD channel  
sizes from 1/12 inch operating with inlet pressures of  
700 psig to the 1/48 inch channel designed to operate  
with 3,000 psig were experimentally studied. Failure  
of gas-breakdown scaling laws prevented the designed  
70 watts from being achieved with the small sizes at  
high pressure. Experimental work on the high voltage  
breakdown of high pressure gases including air,  
Hydrogen, SF6, Argon, Nitrogen CO2, and mixtures using  
various Freons shows a degradation of anticipated  
strength at about 10 to the 8th power V/M. Theoretical  
analyses and experimental measurements have been made  
on the droplet size and density in EFD generators  
using humid air for EFD channel sizes from 1/4 inch to  
1/48 inch. Analyses also include nucleation and growth  
of Mercury and steam. A preliminary design study of  
the short duration airborne 6 MW conversion system and  
a long duration 1 KW and 100 KW ground based system  
using EFD is included.

XII. ELECTRIC POWER ENGINEERING . . . . .	1057
A. General . . . . .	1058
B. Power Cycles . . . . .	1064
C. Siting and Environmental Aspects . . . . .	1066
D. Power Transmission . . . . .	1080

STRATEGIES FOR SCHEDULING POWER PLANTS PRODUCING BOTH HEAT AND ELECTRIC ENERGY

Steven B. Goldman and Michael W. Golay

Energy, vol. 4, no. 6, Dec. 1979, pp. 1033-1051

**Abstract**—The configuration of an optimal energy generation system, which would serve a given energy demand efficiently and economically, is determined. Four plans for the supply of a given, non-transportation community, industrial, and commercial energy load, consisting of steam and electricity requirements, are examined and compared with a current method of generation. Consideration is given primarily to both the utilization of fuel and the economics of power generation.

The primary conclusion of this study is that, with existing technology, it is possible to supply the energy requirements of a specific consumer sector using less fuel and at a lower consumer cost than through the current method of energy generation. The results of the analyses show that the autonomous heat and power method, by which an industrial concern generates all of its electrical and thermal energy requirements using a total energy system (TES), is the configuration of the optimal energy-generation system under current conditions. Cogeneration is an attractive alternative and may be advantageous in certain situations. The dispatched power method, in which the industrial concern operates a TES as a peaking unit for the local utility, has the greatest economic potential if proper utility-industry accommodations can be enacted.

LOAD MANAGEMENT STRATEGIES FOR ELECTRIC UTILITIES:

A PRODUCTION COST SIMULATION, by Peter D. Blair.

Simulation, vol. 32, no. 3, March 1979, p.93-102.

This paper deals with the development and application of a simulation model for analyzing strategies for managing the residential loads of electric utilities. The basic components of the model are (1) a production-cost model, which simulates daily operation of an electric power system, (2) a load model, which disaggregates system loads into appliance loads and other loads, and (3) a comparison model, which compares the production costs and energy consumption needed to meet a particular load profile to the corresponding costs and energy consumption required for another load profile. The profiles in each pair define alternative ways of meeting the same demand.

ELECTRIC POWER LOAD MANAGEMENT: SOME TECHNICAL, ECONOMIC, REGULATORY AND SOCIAL ISSUES, by M. Granger Morgan and Sarosh N. Talukdar.

Proceedings of the IEEE, vol. 67, no. 2, February 1979, p.241-312.

**Abstract**—This paper provides a review of the subject of electric power load management. In Section I, we briefly introduce the topic and then provide a summary of the current operating characteristics of electric energy production and delivery (EED) systems. Section II places load management in the context of the broader set of energy management strategies available to EED systems. The organization and rationale of the paper is then explained. In Section III, we review the set of communication/control technologies available or under development for use in the implementation of load management in EED systems. We provide an assessment of the relative attractiveness of alternative technologies, a brief summary description of a major field demonstration being jointly funded by EPRI and DOE, and two examples which illustrate the state of the art in modern two-way systems.

In Section IV, we review the conventional approach to U.S. electric rate design, describe the current national Electric Utility Rate Design Study, review some important basic ideas of microeconomics, explore the subject of price elasticity of demand, examine the basic ideas underlying marginal cost pricing, discuss some of the practical difficulties of implementing time dependent rates, briefly examine some foreign rate design experience, and conclude by summarizing a number of U.S. rate design experiments sponsored by NSF and by FEA (now DOE). Section V is devoted to an examination of the problems of finding manageable loads in the residential, commercial, industrial, and transportation sectors. Particular attention is given to the development of thermal storage systems for water heating, space heating, and space cooling. Section VI is devoted to summarizing a number of studies which have attempted to assess the short- and long-term economic impacts of load management. The state of the field is such that few definitive cost/benefit statements can be made at this time. A number of potential social impacts are discussed and some broad regulatory policy guidelines are suggested. Finally, in



## SIMULATION OF A SUPERCRITICAL ONCE-THROUGH BOILER

Yutaka Suzuki, Pyong Sil Pak and Yoshihisa Uchida

Simulation, vol. 33, no. 6, Dec. 1979, pp. 181-194.

*The problem addressed is that of improving the control system of an existing supercritical once-through boiler. To do this, it was necessary to construct a dynamic mathematical model of it. This paper describes the model that was developed; it is based on the nonlinear partial differential equations which describe the physical phenomena in the boiler. These equations involve transfer functions that cannot be obtained directly; they were found by linearizing the equations and estimating the values of unknown parameters from the boiler's input-output operational records. The model includes both forward and backward causalities in determining the water and steam flow. Simulation results indicate that the model is valid and that the control system requires modification.*

*The investigated boiler has a capacity of 450 MW and is presently operating at Kainan Thermal Power Station of Kansai Electric Power Company.*

## COAL-FIRED PLANTS EFFICIENT AND RELIABLE.

Electric Power Research Institute, vol 4, no 10, December 1979, p. 18-26.

Traditional opinion holds that power plant efficiency and reliability are a trade-off. But some utilities are attaining both. Building on their success calls for attention to operating practices, R&D troubleshooting, and integrated design of new plant systems.

A79-32451 # Pressurized fluidized bed pilot electric plant - A technology status. S. Moskowitz (Curtiss-Wright Corp., Wood-Ridge, N.J.), G. Weth (U.S. Department of Energy, Washington, D.C.), and A. Leon (Dorr-Oliver, Inc., Stamford, Conn.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-193. 12 p. Members, \$1.50; nonmembers, \$3.00.*

A substantial number of tests directed at providing pressurized fluidized bed combustor (PFBC) performance and heat exchanger material characteristics are conducted in support of the pilot plant design criteria and material selections. PFBC burns high-sulfur coal to produce electricity at competitive costs under environmentally acceptable conditions. It is shown that (1) PFB combustion efficiency in excess of 99% is assured; (2) NO<sub>x</sub> and SO<sub>2</sub> emissions which easily satisfy the current EPA limits are achievable; (3) the air-cooled heat exchanger configuration improves heat transfer performance with the fine bed particle size distribution; and (4) the use of iron- or cobalt-base alloys for the air-cooled heat exchanger tubes is satisfactory for utility life requirements. S.D.

## CONTROL ROOM DESIGN FOR THERMAL POWER PLANTS-- CONSIDERATIONS FOR A MODERN CONCEPT.

J. Candel, Baden.

Brown Boveri Review, vol 66, May 1979, p. 343-350

*The control room is the communication centre of the power plant. All operator commands and interventions required for plant operation can be initiated from this centre.*

*In view of the significant role it plays in power plant operation, it is essential that the control room and its incorporated data presentation techniques be optimized to fulfil the needs of the operating personnel.*

*A fossil-fired, automated 300 MW power plant is used to illustrate a modern concept for control room design and data organization.*

POWER SYSTEM SECURITY MANAGEMENT. K. Reichert, Baden and H. P. Asal, Laufenburg

Brown Boveri Review. vol 66, May 1979  
p. 312-319.

*This paper attempts to systematize to some extent the security monitoring of power systems as a preparatory step towards the development of comprehensive, efficient systems. Such systems are likely to become increasingly important in the future since a number of factors—an increase in interconnections and more rigorous utilization of individual network capacities, the construction of larger power plants and, not least, the provision of larger mutual reserve facilities—are becoming increasingly significant in relation to security in power pool operations.*

#### POWER PLANT PERFORMANCE.

John M. Fowler, Robert L. Goble, & Christoph Hohenemser  
Environment, Vol. 20, No. 3, April 1978, p. 25-32.

The average performance of large coal and nuclear plants has been considerably worse than expected. According to a SIPI task force, the problem for nuclear plants lies with sizes above 800 Megawatts. These differ from smaller plants in their failure to mature.

#### PLANNING FOR UNCERTAINTY.

Margaret Laliberte

EPRI Journal, Vol. 3, No. 4, May 1978, p. 6-

11. Reserve generating capacity costs money, and so does a capacity shortfall. But as future electricity demand becomes harder to forecast, larger planning reserve margins may be more economical in overall cost to consumers.

Mech. Eng., v.100, no.4, Apr.1978.

#### 27 ELECTRIC GENERATION: OPERATING ECONOMICS AND UNIT AVAILABILITY .....

R. W. Sarau

Significant cost savings in electric power generation can be realized by adherence to sound operating and maintenance procedures, assuring that the lowest available heat rate will be maintained.

#### H<sub>2</sub>/O<sub>2</sub> ROCKET ENGINE STEAM GENERATOR FOR FUTURE POWER PLANTS

Josef Reinkenhof and Robert H. Schmucker

J. Energy, vol. 2 no.2, March -April 1978, p100-105

**T**HE hydrogen economy, a concept in which primary energy resources are converted into hydrogen to be distributed throughout the energy market, seems to be an optimal solution to future energy supply.<sup>1</sup> As fossil fuels become increasingly expensive, the nuclear and solar power sources are expected to provide primary energy for hydrogen production.<sup>2</sup> The most basic technical constraint on today's electric utility system is the fact that its product must be produced almost simultaneously with its uncontrolled consumption. If hydrogen is generated and used as an energy carrier, this constraint disappears.<sup>3</sup> The delicate system stability difficulties which may occur in a modern ac transmission grid are not possible in such a high-pressure hydrogen gas pipeline system. Short interruptions in energy generation (for example, control problems in nuclear reactors), would not require techniques for system protection and would not affect the energy-consuming customer at all. The conversion of electricity to hydrogen during off-peak hours and reconversion via hot steam during periods of maximum demand may be a first step into the field of hydrogen economy.<sup>4,5</sup> One of the major components of this cycle is the steam generator<sup>6</sup> which can be developed by applying the well-established hydrogen/oxygen rocket technology.

TIME-OF-DAY PRICING OF ELECTRICAL ENERGY: DOES IT PROMOTE THE PUBLIC INTEREST?, by A. L. Berlad, and F. J. Salzano, R. J. Hoppe and J. Batey. Energy, vol. 3, no. 6, December 1978, p.779-784.

**Abstract**—Time-of-day pricing of electrical energy involves rate incentives designed to encourage a shift of user demand from a utility's peak periods to its off-peak periods. Low "off-peak" rates may also serve as an incentive which encourages large, new, inelastic and/or inefficient uses of electrical energy. In the Long Island, New York, area, installation of air-to-air heat pumps for space heating and cooling may be stimulated by currently proposed time-of-day pricing structures. Possible consequences of a significant market penetration of the Long Island home heating market by the air to air heat pump are considered. In this case, serious questions are raised regarding the ability of the time-of-day rate structure to achieve its espoused aims. This case may be typical of other areas throughout the country.

# BIBLIOGRAPHY ON THE APPLICATION OF PROBABILITY METHODS IN POWER SYSTEM RELIABILITY EVALUATION.

IEEE Transaction on Power Apparatus and Systems, vol. PAS-97, no. 6, Nov./Dec. 1978, p.2235-2242.

**Abstract** - This paper presents a bibliography of selected papers on the subject of power system reliability evaluation.

It includes material which has been made available following the publication of the initial "Bibliography On The Application Of Probability Methods In Power System Reliability Evaluation." (IEEE Transactions PAS-91, No. 2, Mar./Apr. 1972, pp. 649 - 660.) Several publications omitted from the initial bibliography are also included in this extension.

**N78 29631#** Westinghouse Electric Corp., East Pittsburgh, Pa. Advanced Systems Technology Div.  
**METHODOLOGY FOR SOLAR THERMAL POWER PLANT EVALUATION**

J. T. Day Aug 1978 129 p refs Sponsored by Elec. Power Res. Inst.  
(EPRI Proj. 648 1)  
(EPRI ER-869) Avail. NTIS HC A07/MF A01

The development of an evaluation methodology, including process for evaluating solar thermal plant impact on utility reliability and margin requirements and economics, plus the impact of solar plant penetration is presented. In addition to a general methodological framework, specific methods covered include a specific economic calculation methodology, a process for modeling the interdependent operation of a solar plant and the balance of the utility system, a procedure for reserve margin analysis, and a method for solar plant penetration analysis. DOE

TD  
195  
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Thermal effluent disposal from power generation / edited by Zoran P. Zaric. -- Washington : Hemisphere Pub. Corp., c1978.

viii, 375 p. : ill. ; 24 cm. -- (Series in thermal and fluids engineering)

"A publication of the International Centre for Heat and Mass Transfer."

"Lectures presented at the international advanced course on 'Heat disposal from power generation,' held August 23-28, 1976 in Dubrovnik, Yugoslavia"; the course was sponsored by the International Centre for Heat and Mass Transfer.

TK  
1041  
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1978

Aschner, Fritz.

Planning fundamentals of thermal power plants / F. S. Aschner. -- New York : Wiley, c1978.

xii, 738 p.

"A Halsted Press book."

Includes bibliographical references and index.

ISBN 0-470-99356-1

1. Electric power-plants. I. Title.

**N80 10628#** Sandia Labs., Albuquerque, N. Mex.  
**SENSITIVITY STUDY OF BRAYTON CYCLE POWER PLANT PERFORMANCE**

Carl C. Hiller Aug 1978 36 p refs  
(Contract EY-76-C-04-0789)  
(SAND 78-8020) Avail. NTIS HC A03/MF A01

The efficiency of Brayton cycle power plants is investigated. The parameters and configurations examined include open and closed air cycles, optimum pressure ratio, helium versus air working fluids, turbine and compressor isentropic efficiencies, recuperator effectiveness, turbine inlet temperature, heat rejection temperature, pressure drop losses, with/without intercooling, and with/without reheat. Equation derivations, a computer listing, and a hand calculator program listing are included. DOE

NASA-CP-2019

N77-30276\*# Alabama Power Co., Birmingham  
 IMPACT OF ALTERNATIVE ENERGY FORMS ON PUBLIC UTILITIES  
 F. W. Keith, Jr. In NASA Marshall Space Flight Center Proc. of the ASPE/MSFC Symp. on Eng. and Productivity Gains from Space Technol. May 1977 p 19-31 (For primary document see N77-30273 21-31)  
 Avail. NTIS HC A13/MF A01 CSCL 10A

TJ Energy development III / sponsored by the IEEE  
 153 Energy Development Subcommittee of the IEEE  
 .E4783 Power Generation Committee of the IEEE Power  
 pt.3 Engineering Society. -- New York : Institute of Electrical and Electronics Engineers, c1977.

170 p. : ill. ; 28 cm. -- (IEEE Power Engineering Society Papers ; 3)

"77CH1215-3-PWR"

"Papers presented at the National Power

Power Generation in Canada to 2000 A.D., by K. L. Broe... p.168...

Mechanical Engineering, v.99, no.12, Dec.1977.

41 FOSSIL-FUELED POWER PLANT DESIGN: EUROPEAN STYLE .....  
 ..... H. Kuerlen and H. Termuehlen  
 West European power transmission systems are designed and operated differently than those in the U.S. Here's a look at some of the reasons why.

TN Offshore and underground power plants /  
 871.3 edited by Robert Noyes. -- Park Ridge,  
 .044 Noyes Data Corporation, 1977.  
 xii, 308 p. : ill. ; 24 cm.  
 Bibliography: p. 308.  
 ISBN 0-8155-0680-5  
 1. Power-plants. 2. Offshore oil industry. 3. Atomic power plants--Offshore. I. Noyes, Robert.

TK IEEE Power Engineering Society.  
 5 Text of "A" papers from the winter meeting, New York, N.Y., January 30- February 4, 1977 / IEEE Power Engineering Society. -- New York : Institute of Electrical and Electronics Engineers, c1977.  
 .I25 1 v. in various pagings : ill.  
 1977 77CH1190-A-PWR  
 1. Electric engineering--Congresses. 2. Electric power--Congresses. I. Title.

Automatica, v.13, no.6, p.579-593.

Nov.  
 1977

LARGE SCALE CONTROL PROBLEMS IN ELECTRIC POWER SYSTEMS. Giorgio Quazza.

Summary The main large-scale control problems in electric power system operation, from optimal allocation of generation and transmission resources to network state estimation, frequency and exchange power control, system stability and dynamic security, are illustrated and the methods presently used to solve them are recalled. Special attention is given to significant applications of decomposition by physical decoupling and relaxation or by time-division of decentralized controls, of coordination and hierarchies, with a brief mention of large system analysis areas open to further development.



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Offshore and underground power plants.

Robert Noyes, Ed.

Noyes Data Corp. 1977.

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Includes bibliographic references.  
1. Power resources—Congresses.  
2. Electric power—Congresses. I.  
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Power Generation Committee. Energy Develop-  
ment Subcommittee. II. Series.

A Forecast of Electric Power Generation Technology -- 1975-2000. *pt. 56...*  
by L. G. Hauser.....



## ELECTRIC POWER ENGINEERING - POWER CYCLES

**N80-10606#** Westinghouse Electric Corp., Eddystone, Pa.  
**SCREENING EVALUATION OF NOVEL POWER CYCLES  
INTEGRATED WITH GASIFICATION PLANTS** Final Report  
R. W. Foster-Pegg and R. V. Garland Feb. 1979 136 p  
(Contract EPRI Proj 990-3)  
(EPRI-AF-1002) Avail: NTIS HC A07/MF A01

Three basic plant configurations were studied: (1) the condensing combined cycle, which includes combustion turbines, gas expanders and condensing steam turbines; (2) the single cycle, which is comprised of combustion turbines and gas expanders, but no steam turbines; and (3) the noncondensing combined cycle, which utilizes combustion turbines, gas expanders and a non-condensing steam turbine. The most efficient plant configuration studied included a non-condensing steam turbine. The best plant heat rate calculated for this configuration is 7956 Btu/Kwh.  
DOE

**N80-10595\*** National Aeronautics and Space Administration  
Lewis Research Center, Cleveland, Ohio.  
**NASA-LEWIS CLOSED-CYCLE MAGNETOHYDRODYNAMIC  
PLANT ANALYSIS**  
Paul F. Penko 1979 13 p refs Presented at Closed-Cycle  
Magnetohydrodynamics Specialists Meeting, Bozeman, Montana,  
21 Jun. 1979  
(Contract EF-77-A-01-2674)  
(NASA-TM-79249; DOE/NASA-2674-79/7; E-159) Avail:  
NTIS HC A02/MF A01 CSCL 10A

A brief review of preliminary analyses of coal fired closed cycle MHD power plants is presented. The performance of three power plants with differing combustion systems were compared. The combustion systems considered were (1) a direct coal-fired combustor, (2) a coal gasifier with in-bed desulfurization and (3) a coal gasifier requiring external fuel gas cleanup. Power plant efficiencies (auxiliary power excluded) were 44.5, 43, and 41 percent for the three plants, respectively.  
R.E.S.

**COMBINED GAS/STEAM TURBINE POWER PLANTS THE PRESENT  
STATE OF PROGRESS AND FUTURE DEVELOPMENTS**, by  
A. Wunsch,  
Brown Boveri Review, vol. 65, October 1978, p.646-655.

*Combined gas/steam turbine plants are becoming increasingly common by reason mainly of the high efficiencies. The contribution presents a review of the arrangements which can be provided today, and of the attainable outputs and efficiencies.*

**Brown Boveri Review, v.65,**

**Oct.  
1978**

**POWER PLANTS WITH COMBINED GAS/STEAM CYCLES.  
(Special issue).**

**N79-28736#** Kraftwerk Union A.G. Reaktortechnik, Erlangen  
(West Germany)  
**COMBINED GAS/STEAM TURBINE POWER PLANTS WITH  
SUPPLEMENTARY FIRING**  
J. Charlier and H. Brueckner In Von Karman Inst for Fluid  
Dyn. Combined Cycles for Power Generation, Vol 1 1978  
59 p refs (For primary document see N79 28732 19 44)  
Avail: NTIS HC A14/MF A01

Combined cycles systems are analyzed, especially those in the high power range. A coal and natural gas fired combined cycles power plant with a 750 MW output is described. Most of the power is produced by the steam turbine arrangement in which additional firing is involved. An efficiency on the order of 40 percent to 42 percent is obtained. Further applications of combined cycles and new developments in Germany are discussed.

Author (ESA)

# COMPUTER CONTROL OF COMBINED-CYCLE POWER PLANTS.

Robert Uram.

IEEE Spectrum, v.14, no.10, Oct.1977, p.36-41.

Combined-cycle power plants using gas-turbine and steam-turbine technology have a number of features that make them attractive to the electric utility industry—including low capital investment per kilowatt of generation; low daily operational costs; and capability for use as a base-load unit as well as a peaking station, with very fast start capabilities. And there is increasing interest in future use of low-energy gas from coal for combined-cycle power plants. Since this gas is clean burning, some air pollution problems can be avoided compared with power plants dependent on coal-fired steam generation by itself.

TJ 163.9 Energy technology handbook : prepared by 142 specialists / Douglas M. Considine, editor-in-chief. -- New York : McGraw-Hill, c1977. .E54 1874 p. in various pagings : ill. ; 24 cm. Includes index.

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## ELECTRIC POWER ENGINEERING - SITING AND ENVIRONMENTAL ASPECTS

RISK WITH ENERGY FROM CONVENTIONAL AND NONCONVENTIONAL SOURCES, by Herbert Inhaber.  
Science, vol. 203, no. 4382, February 1979, p.718-723.

*Summary.* Risk to human health was compared for five conventional and six non-conventional energy systems. The entire cycle for producing energy was considered, not just part. The most important conclusion drawn is that the risk to human health from nonconventional sources can be as high as, or even higher than, that of conventional sources. This result is produced only when the risk per unit energy is considered, rather than the risk per solar panel or windmill. The risk from non-conventional energy sources derives from the large amount of material and labor needed, along with their backup and storage requirements. Risk evaluation is a relatively new discipline, and therefore the results presented here can be considered only a beginning. However, society should keep relative risk in mind when evaluating present and future energy sources.

CHARACTERIZATION AND FORMATION OF SUBMICRON PARTICLES IN COAL-FIRED PLANTS. R.D. Smith, J.A. Campbell and K.K. Nielson.

Atmospheric Environment, vol 13, no 5, 1979, p. 607-617.

*Abstract.* Submicron particles resulting from pulverized coal combustion in coal-fired steam plants have been chemically characterized and the results interpreted in terms of various mechanisms for their formation. Elemental analyses using XRF, AA, and INAA techniques are reported for approximately 60 elements for flyash from two large coal-fired plants. The concentrations of elements volatilized during combustion are independent of particle size in the submicron size range, in contrast to the larger particle sizes where an inverse relationship with particle size applies. Scanning electron micrographs show the submicron particles are also much more homogeneous than larger flyash particles, while still showing evidence of some surface enrichment in ESCA studies. Various mechanisms for formation of submicron particles have been considered. The present results are most consistent with formation of submicron particles by the bursting of larger particles due to gas release during rapid heating, followed by coagulation and condensation of volatilized elements to form particles in the 0.1-1.0  $\mu$ m size range. The importance of this mechanism in other coal-fired plants is probably dependent on both temperature and ash composition.

THE ENVIRONMENTAL AND PUBLIC HEALTH CONSEQUENCES OF REPLACEMENT ELECTRICITY SUPPLY.

Richard Wilson.

Energy, vol 4, no 1, February 1979, 81-86.

*Abstract.*—The usual problem discussed by environmentalists is the total environmental impact of an electricity generating plant while it is generating electricity. However, a plant is part of a system and cannot be treated in isolation. Provided no generating shortage develops, almost the same amount of electricity will be generated in any case, but in different ways. Although a good case can be made for spending money on reducing electricity demand instead of on generating capacity, this is not well discussed in the context of an individual power station.

BIOASSAYS FOR ESTIMATING HEALTH HAZARDS OF NEW ENERGY TECHNOLOGIES.

Energy and Technology Review, Jan. 1979, p.16-23.

*We are developing a number of bioassays to determine whether the effluents of in situ shale-oil and coal-gas recovery processes contain genetic toxicants—substances that may modify the genetic material of cells and thereby cause mutations leading to cancer. Our procedure is to obtain water from wells near the in situ experiments, concentrate it, fractionate it into chemical classes, and test each fraction with a series of bioassays. In this series of tests, we use bacteria to screen the substances for mutagenic activity, animal cell-cultures to confirm the activity, and whole animals to approximate mutagenic activity in humans. Results to date indicate that these bioassays are sensitive enough to detect small amounts of potentially hazardous substances in dilute effluents.*

79A38372 ISSUE 1C PAGE 2993 CATEGORY 35  
79/06/00 9 PAGES UNCLASSIFIED DOCUMENT

UTTL: Temperature measurement of cooling water discharged  
from power plants

AUTH: A/SCHOTT, J. R. PAA: A/(Calspan Corp., Buffalo,  
N.Y.)

Photogrammetric Engineering and Remote Sensing, vol.  
45, June 1979, p. 753-761. Research sponsored by the  
New York State Energy Research and Development  
Authority.

MAJS: /\*AERIAL RECONNAISSANCE/\*INFRARED SCANNERS/\*POLLUTION  
MONITORING/\*TEMPERATURE MEASUREMENT/\*THERMAL POLLUTION  
/\*WATER POLLUTION

MINS: / CALIBRATING/ COOLING SYSTEMS/ EFFLUENTS/ INFRARED  
IMAGERY/ POWER PLANTS

ABA: S.D.

ABS: The paper discusses an airborne calibration technique  
for a thermal IR scanner, along with the experimental  
test program. The technique involves the development  
of a model relating the signal at the sensor to the  
surface temperature and the atmospheric effects  
contributing to the signal at the sensor. It is shown  
how the radiant energy detected by the sensor at  
aircraft altitudes of about 600 m is not only a  
function of temperature but also is functionally  
dependent on atmospheric and background terms. The  
calibration technique for temperature measurement of  
cooling water discharged from powerplants is  
successfully tested. Future efforts in this field are  
recommended to be directed at techniques designed to  
generate thermal maps with appropriate corrections at  
angles away from the vertical.

#### ENERGY: WHAT ABOUT THE WASTE?

M. I. Goldman

Chemical Engineering Progress, vol. 75, no. 11,  
Nov. 1979, pp. 65-69.

#### 14322 REGIONAL POWER PLANT SITING MODEL

KEY WORDS: Air pollution; Facilities management; Mathematical models;  
Power plant location; Powerplants; Site selection; Water resources

ABSTRACT: A linear programming model for long-range regional power plant siting is  
presented. Designed for use in energy planning studies as a bridge between energy  
scenarios and environmental transport models, it can also be used by siting agencies to  
analyze alternative siting strategies in terms of cumulative environmental impacts on a  
region, and to assess the economic penalties associated with various regulatory strategies.  
The model includes consideration of air, water, and land-use constraints, and is applied to  
the New York Power Pool in a simulation of the impact of various air pollution control  
strategies.

REFERENCE: Meier, Peter M., "Long-Range Regional Power Plant Siting Model,"  
*Journal of the Energy Division, ASCE*, Vol. 105, No. EY1, Proc. Paper 14322, January,  
1979, pp. 117-135

#### TWO COAL COMBUSTION ALTERNATIVES: REDUCING POLLUTION POTENTIAL. D. I. Dykstra, K. J. Shields.

Coal Processing Technology, vol 5, 1979, p. 141-145.

#### THE ENVIRONMENTAL AND PUBLIC HEALTH CONSEQUENCES OF REPLACEMENT ELECTRICITY SUPPLY, / Richard Wilson. Energy, vol. 4, no. 1, Feb. 1979, p.81-87.

Abstract—The usual problem discussed by environmentalists is the total environmental impact of an  
electricity generating plant while it is generating electricity. However, a plant is part of a system and cannot  
be treated in isolation. Provided no generating shortage develops, almost the same amount of electricity will  
be generated in any case, but in different ways. Although a good case can be made for spending money on  
reducing electricity demand instead of on generating capacity, this is not well discussed in the context of an  
individual power station.

1979  
09920



**KEY WORDS:** Air quality standards; Ambient air quality; Control systems; Emissions; Energy budget; Energy methods; Federal laws; Public health

**ABSTRACT:** The current national energy goals are to increase the use of coal and nuclear fuels, thereby decreasing the Nation's dependence on foreign oil, and also increase conservation activities. Solar and other inexhaustible sources of energy are expected to be in widespread use by early in the 21st century. The Clear Air Act Amendments of 1977 require that air quality regulations for sulfur oxides and particulate matter become more stringent and below the level that scientific evidence indicates is necessary to protect public health and welfare. In order to achieve both environmental and energy goals concurrently, coal-fired generators could be provided with a single environmental control that would be more effective in protecting ambient air quality than multiple individual controls. An electrically driven heat pump is better than that of directly fired oil or gas units.

**REFERENCE:** Jameson, Robert M., and Kane, Robert, "Are Environmental Regulations Attaining a Realistic Balance among Energy and Environmental Goals," *Journal of the Environmental Engineering Division*, ASCE, Vol. 105, No. EE1, Proc. Paper 14389, February, 1979, pp. 121-134

# LOW LEVELS EFFECT OF NITROGEN OXIDES EMITTED BY POWER STATION. K. Jacyszyn and W. Lesiecki.

Journal of Environmental Science and Health,  
vol A14, no 6, 1979, p. 519-527.

**NEO-10631#** Department of Energy, Washington, D. C. Div. of Technology Assessments.

## ENVIRONMENTAL READINESS OF EMERGING ENERGY TECHNOLOGIES Summary Report

Jan. 1979 77 p

(DOE/ERD-0022) Avail: NTIS HC A05/MF A01

The principal conclusions of the 21 Environmental Readiness Documents, which assessed 24 technologies are presented. Seven technologies were judged to have minimal environmental constraints. Four are solar technologies. The minimally constrained technologies nevertheless have some potential environmental, health, and safety problems, which will require careful management. Eleven technologies, many of which are high-technology systems with great promise for meeting the Nation's energy needs, were judged to have moderate environmental constraints.

The moderately constrained technologies are, with few exceptions, in the predemonstration stage, with demonstration and environmental readiness likely to be achieved by 1980-1990. Six technologies, enhanced oil recovery (micellar polymer), hydrothermal, coal gasification, coal liquefaction, diesel cogeneration, and in situ oil shale, were judged to have significant environmental constraints that will require extensive environmental research and development before they can be widely used or before they can be deployed in some environmentally sensitive areas. DOE

79A53624 ISSUE 24 PAGE 4567 CATEGORY 47  
78/00/00 10 PAGES UNCLASSIFIED DOCUMENT  
**UTTL:** A numerical study of meteorological effects of waste heat and moisture releases from hypothetical power parks  
**AUTH:** A/RAO, K. S.; B/HOSKER, R. P. PAA: B/(NOAA, Atmospheric Turbulence and Diffusion Laboratory, Oak Ridge, Tenn.)  
In: Environmental effects of atmospheric heat/moisture releases: Cooling towers, cooling ponds, and area sources; Proceedings of the Second Thermophysics and Heat Transfer Conference, Palo Alto, Calif., May 24-26, 1978. Conference sponsored by the American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers, New York, American Society of Mechanical Engineers, 1978, p. 97-106.  
**MAJS:** /\*ATMOSPHERIC MODELS/\*ATMOSPHERIC TURBULENCE/\*CLOUDS (METEOROLOGY)/\*ELECTRIC POWER PLANTS/\*METEOROLOGICAL PARAMETERS/\*THERMAL POLLUTION/\*WEATHER MODIFICATION  
**MINS:** /ATMOSPHERIC MOISTURE/ATMOSPHERIC TEMPERATURE/BOUNDARY VALUE PROBLEMS/LIQUID-VAPOR INTERFACES/MATHEMATICAL MODEL\*/PLUMES/VERTICAL DISTRIBUTION/WATER VAPOR/WIND DIRECTION/WIND VELOCITY  
**ABA:** (author)  
**ABS:** A two-dimensional nonprecipitating shallow cloud model has been developed for the Meteorological Effects of Thermal Energy Releases (METER) program. This second-order-closure turbulence model utilizes a full set of equations for mean wind velocities, potential temperature, specific humidity, and liquid water content, as well as equations for the corresponding turbulent fluxes which are closed approximately. Vapor-liquid water phase changes are included in terms of saturation adjustments. A hypothetical power park was treated as an area source with idealized distributions of waste heat and water vapor fluxes from several cooling towers. These fluxes were utilized as boundary conditions to the model. Numerical experiments were performed for a 10,000 Mwe power park in a convective atmosphere with variable surface relative humidity and mean wind direction. The total waste heat flux over the power park area was also arbitrarily varied. Preliminary results presented include typical vertical profiles of mean potential temperature, specific humidity, and liquid water in the atmosphere, as well as perturbations in the surface temperature and humidity due to the power park.



CH-150,525 1978  
 PREDICTION OF TURBULENT JETS AND PLUMES IN  
 FLOWING AMBIENTS. Shinh-Sing Hwang. (Thesis -  
 Ph.D.) 1978. 173p.

Iowa State Univ.,  
 Ames

Thermal pollution  
 Jets, Turbulent  
 Flow - Jets  
 Exhaust stacks - Plumes  
 Power sources - Pollution  
 Power plants - Siting

A79-14106 Energy and the environment; Proceedings of  
 the Fifth National Conference, Cincinnati, Ohio, November 1-3,  
 1977. Conference sponsored by the AIChE, APCA, and Dayton  
 Affiliate Societies Council. Edited by D. G. Nichols, E. J. Rolinski  
 (USAF, Materials Laboratory, Wright-Patterson AFB, Ohio), R. A.  
 Servais (Dayton, University, Dayton, Ohio), L. Theodore, and A. J.  
 Buonicore (Entoleter, Inc., Hamden, Conn.). Dayton, Ohio, Ameri-  
 can Institute of Chemical Engineers, 1978. 607 p. (For individual  
 items see A79-14107 to A79-14125)

Consideration is given to such topics as energy conservation,  
 waste disposal and utilization, methodology for the assessment of  
 energy and environment, energy system studies, general air pollution  
 control studies, coal preparation and cleaning, and alternate energy  
 sources. Papers are also presented in such fields as regional  
 energy/environment assessment studies, sulfur-dioxide control, par-  
 ticulate removal, water pollution control, health considerations in  
 energy conversion, and social and economic energy/environment  
 impact assessment.

B.J.

T1163 2.116 V 3 RR

A79-14722 Environmental impacts of industrial energy  
 systems in the coastal zone. C. A. S. Hall (Cornell University, Ithaca,  
 N.Y.); Woods Hole Oceanographic Institution, Woods Hole, Mass.), R.  
 Howarth (Woods Hole Oceanographic Institution, Woods Hole,  
 Mass.), B. Moore, III (Woods Hole Oceanographic Institution, Woods  
 Hole, Mass.; New Hampshire, University, Durham, N.H.), and C. J.  
 Vorosmarty (New Hampshire, University, Durham, N.H.). In: Annual  
 review of energy. Volume 3. (A79-14718 03-44) Palo Alto, Calif.,  
 Annual Reviews, Inc., 1978, p. 395-475. 673 refs. Research  
 supported by the Leslie F. and Lola Hubbart Fund and Woods Hole  
 Oceanographic Institution.

The presented review has the primary objective to provide a  
 clear and meaningful picture of the major issues, which merit critical  
 public evaluation, by characterizing the environmental problems  
 associated with construction and operation of energy facilities in the  
 coastal zone, and by describing some attempts at 'solving' them.  
 Attention is given to oil and electricity systems since they provide,  
 by far, the most important and potentially serious direct environ-  
 mental impositions on the coastal zone. The review shows that the  
 coastal regions of the U.S. are relatively rare, biologically important,  
 and vulnerable to anthropogenic perturbation. The coastal zone has  
 been and will probably continue to be important in the industrial  
 development of the nation. The placement of energy facilities there  
 generates environmental impacts and creates conflicts in the utiliza-  
 tion of the U.S. coastal resources.

G.R.

TT  
 163.2 Annual review of energy, v. 3 / Jack M.  
 .A6 Hollander, editor ; Melvin K. Simmons,  
 v.3 David O. Wood, associate editors. —  
 Palo Alto, Calif. : Annual Reviews, 1978.  
 544 p.  
 Includes bibliographical references  
 and index.  
 ISEN 0-8243-2303-3  
 1. Power resources—Addresses, essays,  
 lectures. 2. Energy conservation—

ENVIRONMENTAL IMPACTS OF INDUSTRIAL ENERGY SYSTEMS  
 IN THE COASTAL ZONE. Charles A. S. Hall, Robert Howarth,  
 Berrien Moore, III, and Charles J. Vorosmarty

395

TJ123.2  
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A79-14721      Energy technologies and natural environments  
- The search for compatibility. J. Harte and A. Jassby (California, University, Berkeley, Calif.). In: Annual review of energy. Volume 3. (A79 14718 03-44) Palo Alto, Calif., Annual Reviews, Inc., 1978, p. 101-146. 123 refs.

An investigation is conducted regarding the impact which present and future energy activities will have upon ecosystems. An overview of the major energy activities is presented, taking into account hydropower, solar space heating and cooling, biomass conversion, wind conversion, the solar central receiver system, ocean thermal conversion, geothermal conversion, surface mining of coal, deep mining of coal, the cooling requirements of electric generating plants, the combustion of fossil fuels, petroleum in the environment, the nuclear fuel cycle, oil shale mining and conversion, energy conversion, and cross-technology comparisons. It is found that the various energy sources and technologies differ greatly in the type and degree of ecological risk they pose to nature and to society. The solar technologies, with some important exceptions, are relatively benign. Others such as oil shale and coal conversion to synthetic fuels and hydroelectric power can generate quite serious impacts on ecosystems.

G.R.

A RATIONAL APPROACH TO POWER PLANT SITING, by Francis H. Cummings, and Peter B. Clark.  
IEEE Spectrum, vol. 15, no. 12, December 1978, p. 48-52.

**A technique that integrates economic, environmental, and site-specific data could result in better decisions**

AICHE Symposium Series, v.74,      1978  
no.175.

CONTROL AND DISPERSION OF AIR POLLUTANTS: EMPHASIS ON NO<sub>x</sub> AND PARTICULATE EMISSIONS. R.L. Byers, D.W. Cooper and William Licht, eds. (Selected papers from 1976 AICHE Meetings held Kansas City, Mo., Atlantic City, N.J. and Chicago, Ill.)

American Institute of Chemical  
Engineers

## ENERGY RESOURCE DEVELOPMENT: THE MONITORING COMPONENTS

George B. Morgan  
Environmental Science & Technology  
Vol. 12, no.1, January 1978,  
p. 34-43.

*At the same time that this nation is developing its coal resources in the western part of the U.S., it is developing air & water instrumentation and monitoring techniques to ensure adequate surveillance and safeguards protective of health and welfare. George Morgan, director of the EPA Environmental Monitoring and Surveillance Laboratory, tells ES&T readers of the activities of eight different federal agencies to determine the source, the transport, and fate of environmental pollutants.*

79A17229    ISSUE 5    PAGE 870    CATEGORY 45    78/00/00  
10 PAGES    UNCLASSIFIED DOCUMENT

UTTL: Power generation and ambient air quality monitoring  
AUTH: A/OHEARE, J.    PAA: A/(Victoria, State Electricity Commission, Australia)

In: International Clean Air Conference, Brisbane, Australia, May 15-19, 1978, Proceedings. (A79-17226 05-45) Ann Arbor, Mich., Ann Arbor Science Publishers, Inc., 1978, p. 37-46.

MAJS: /\*AIR POLLUTION/\*AIR QUALITY/\*ELECTRIC POWER PLANTS/\*  
POLLUTION CONTROL/\*POLLUTION MONITORING  
MINS: / ATMOSPHERIC CIRCULATION/ AUSTRALIA/ GROUND STATIONS/  
PUBLIC HEALTH/ REAL TIME OPERATION/ STANDARDS/ SULFUR  
DIOXIDES

ABA: B.J.

ABS: Pollution control legislation adopted in the United States and Western Europe is examined in an effort to provide industry with information on pollution control philosophy and standards which might be adopted in Australia. Short-term concentrations are becoming increasingly important because of the short-term standards being promulgated, and it can be expected that monitoring systems capable of real-time measurements will find increasing use in Australia. Certain air pollution problems based on the long-range transport of emissions require measurements over wide geographical areas and are often effectively investigated through a cooperative approach by a number of organizations.

**Progress in Water Technology,  
v.10, no.6.**

1978

**WATER POLLUTION RESEARCH, NINTH INTERNATIONAL  
CONFERENCE. PART 2. S.H. Jenkins, ed.  
(Sponsored by IAWPR. Held Stockholm, Sweden,  
June 12-16, 1978).**

**International Association on  
Water Pollution Research  
International Conference on  
Water Pollution Research**

**June 12-16,  
1978**

T.-Y. J. Chu, P. A. Krenkel and 801 Wastewater control technology in steam-electric  
R. J. Ruane power plants

The Tennessee Valley Authority has been monitoring surface water discharges from its 12 coal-fired power plants since 1967. The first discharges to be monitored were the effluents from ash settling ponds. Then, discharges from other sources (e.g., boiler blowdown, chemical cleaning wastes, coal pile drainage, cooling tower blowdown, and wet scrubber wastes) were included in this monitoring. Samples from these discharges were analyzed for about 30 parameters including trace metals. Several contaminants in these discharges, unless treated, may have potential for causing adverse environmental effects. The characteristics of these discharges are delineated. The wastewater treatment, including water recycle and reuse, for reducing pollutants contained in waste streams are evaluated in order to conform with the current and future restrictions. An inexpensive control technology for treating several power plant waste streams is the combined treatment with ash pond water. The advantage of this combined treatment process is the overall simplicity and low cost as compared to dry disposal of ashes and treatment of individual waste streams. Trace metals leaching from the ash disposal pond into the ground water are high in concentrations; but due to low permeability rates, the mass flow of trace metals in the surface discharge is much greater than that through ground water leaching.

**STRATEGY FOR THE SITING OF ELECTRIC ENERGY  
FACILITIES.**

Jeffrey P. Richetto  
Public Utilities Fortnightly, Vol. 101, No.  
13, June 1978, p. 29-33

A proposal of procedures to be followed in the selection of sites for electric power generating plants

79N18363# ISSUE 9 PAGE 1146 CATEGORY 73  
78/10/00 15 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Disposal of power plant wastes  
AUTH: A/JONES, J. W.  
CORP: Environmental Protection Agency, Research Triangle  
Park, N.C. CSS: (Industrial Environmental Research  
Lab.) AVAIL:NTIS SAP: HC A12/MF A01  
In Automation Industries, Inc. Energy/Environment 3  
p 275-289 (SEE N79-18352 09-42)  
MAJS: /\*ELECTRIC POWER PLANTS/\*ENVIRONMENT POLLUTION/\*  
INDUSTRIAL WASTES/\*WASTE DISPOSAL  
MINS: / AIR POLLUTION/ CHEMICAL ANALYSIS/ COMBUSTION  
PRODUCTS/ COST ESTIMATES/ CRYSTAL GROWTH/ POLLUTION  
CONTROL/ REGULATIONS/ WATER POLLUTION  
ABA: G.Y.  
ABS: The generation and disposal of solid wastes produced  
by power plants is discussed. A summary of effluent  
guidelines and standards for Steam-electric power  
plant ash ponds is given. State regulation and a waste  
and water program are also discussed, with a table of  
projects for the program provided. The physical and  
chemical properties of flue gas cleaning wastes are  
briefly described. Estimating cost reduction is also  
discussed.

79A17249 ISSUE 5 PAGE 792 CATEGORY 31 78/00/00  
18 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Advanced emissions control and test facility of the  
Electric Power Research Institute  
AUTH: A/TASSICKER, O. J.; B/SPENCER, H. W., III PAA:  
A/(Electric Power Research Institute, Palo Alto,  
Calif.); B/(Western Precipitation Corp., Los Angeles,  
Calif.)  
In: International Clean Air Conference, Brisbane,  
Australia, May 15-19, 1978, Proceedings. (A79-17226  
05-45) Ann Arbor, Mich., Ann Arbor Science Publishers,  
Inc., 1978, p. 469-486. Research supported by the  
Electric Power Research Institute.  
MAJS: /\*AIR POLLUTION/\*ELECTRIC POWER PLANTS/\*EXHAUST GASES  
/\*POLLUTION CONTROL/\*PRECIPITATORS/\*SMOKE ABATEMENT/\*  
TEST FACILITIES  
MINS: / CLEAN ENERGY/ DUST COLLECTORS/ EFFLUENTS/ FLUES/  
NITROGEN OXIDES/ SULFUR OXIDES  
ABA: M.L.  
ABS: A facility for testing devices that remove  
particulates, SOx, and NOx is described, and  
preliminary results for a two-stage precipitator are  
reported. The facility, which utilizes boiler flue-gas  
side streams, can test devices at flows from 1 to 20  
cu m/sec. Data on all process parameters are analyzed  
and displayed in real time. The tested precipitator  
which is described, uses a high-intensity ionizer  
array followed by four conventional collector fields.  
Corona V-I characteristics are reported.

78A41279 ISSUE 17 PAGE 3129 CATEGORY 45  
78/00/00 7 PAGES UNCLASSIFIED DOCUMENT

UTTL: Transport of SO<sub>2</sub> in power plant plumes - Day and night

AUTH: A/SMITH, T. B.; B/BLUMENTHAL, D. L.; C/ANDERSON, J. A.; D/VANDERPOL, A. H. PAA: D/(Meteorology Research, Inc., Altadena, Calif.)  
(International Symposium on Sulfur in the Atmosphere, Dubrovnik, Yugoslavia, Sept. 7-14, 1977.) Atmospheric Environment, vol. 12, no. 1-3, 1978, p. 605-611.  
Research supported by the U.S. Environmental Protection Agency.

MAJS: /\*AIR POLLUTION/\*ATMOSPHERIC DIFFUSION/\*ELECTRIC POWER PLANTS/\*PLUMES/\*SULFUR DIOXIDES

MINS: / DIURNAL VARIATIONS/ POLLUTION MONITORING/ ST LOUIS-KANSAS CITY CORRIDOR (MO)/ TRAJECTORY ANALYSIS/ WIND PROFILES

ABA: (Author)

ABS: The long-range transport of SO<sub>2</sub> and other pollutants emitted from the 216-m stack of a 2000-MW coal-fired power plant has been documented during both day and night summer conditions. Aircraft measurements and trajectory analyses showed that SO<sub>2</sub> emitted during the late morning hours of one day underwent rapid mixing near the plant. Once mixed through the mixing layer, the plume maintained its identity. In the evening, a surface radiation inversion formed, thermally driven mixing ceased, and the lapse rate aloft became more stable. Although winds less than 4 m/s existed at the surface, the winds were 8-15 m/s for most of the night. SO<sub>2</sub> emitted during the day became decoupled from the ground and was shown to be transported more than 300 km by midnight in the high-wind-speed region aloft. The SO<sub>2</sub> emitted at night remained decoupled from the ground and experienced much less dilution. At 75 km in the night-emitted plume, the peak SO<sub>2</sub> concentration was greater than 0.85 ppm. The stable night regime is important for the long-range transport of sulfur compounds in the air.

79A15922 ISSUE 4 PAGE 663 CATEGORY 45 78/00/00  
6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Coal-based electricity and air pollution control - A case for solvent refined coal

AUTH: A/HARRISON, W. B.  
In: Energy technology V: Challenges to technology; Proceedings of the Fifth Conference, Washington, D.C., February 27-March 1, 1978. (A79-15879 04-44)  
Washington, D.C., Government Institutes, Inc., 1978, p. 1002-1007.

MAJS: /\*AIR POLLUTION/\*COAL LIQUEFACTION/\*COAL UTILIZATION/\* COMBUSTION PRODUCTS/\*ELECTRIC POWER PLANTS/\*ENERGY TECHNOLOGY/\*POLLUTION CONTROL/\*SOLVENT EXTRACTION

MINS: / FLUIDIZED BED PROCESSORS/ REFINING/ SULFUR DIOXIDES/ TECHNOLOGY ASSESSMENT

78A46023 ISSUE 20 PAGE 3670 CATEGORY 45 CNT#:  
W-7405-ENG-48 78/00/00 11 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Elemental particle-size emissions from coal-fired power plants - Use of an inertial cascade impactor

AUTH: A/ONDOV, J. M.; B/RAGAINI, R. C.; C/BIERMANN, A. H. PAA: C/(California, University, Livermore, Calif.)  
Atmospheric Environment, vol. 12, no. 5, 1978, p. 1175-1185.

MAJS: /\*AIR POLLUTION/\*COAL/\*COMBUSTION PRODUCTS/\*PARTICLE EMISSION/\*PARTICLE SIZE DISTRIBUTION/\*POWER PLANTS

MINS: / CHEMICAL COMPOSITION/ ELECTRON MICROSCOPY/ ERROR ANALYSIS/ MASS DISTRIBUTION/ NEUTRON ACTIVATION ANALYSIS/ PARTICLE DENSITY (CONCENTRATION)/ PARTICLE DIFFUSION/ PARTICLE MASS/ SIZE DETERMINATION/ TABLES (DATA)

ABA: M.L.

ABS: Coal-fly-ash particles collected on coated and uncoated impaction substrates were analyzed by scanning electron microscope techniques in combination with instrumental neutron activation analysis to verify the sizes and elemental composition of collected particles. The results were used to estimate the significance of bounce-off and reentrainment onto back-up filters and to evaluate wall and interstage losses for the University of Washington MK III Source Test Cascade Impactor. Particles were analyzed for a total of 39 elements. Characteristics of particles collected downstream from an electrostatic precipitator and of particles collected on back-up filters are described. Wall and interstage losses of most elements were estimated to be about 40% of mass. A wet scrubber and coated impaction substrates did not greatly reduce bounce-off and reentrainment of small wet particles.

79N24675# ISSUE 20 PAGE 2699 CATEGORY 44 RPT#:  
PB-294270/4 WRR1-BULL-36 W79-05796 OWRT-A-062-ALA(1)  
79/03/00 33 PAGES UNCLASSIFIED DOCUMENT

UTTL: The effect of water pollution control regulations on the cost of production of electric power TLSP: Final Report

AUTH: A/DEYAK, T. A.; B/LINK, A. N.  
CORP: Auburn Univ., Ala. CSS: (Water Resources Research Inst.) AVAIL:NTIS SAP: HC A03/MF A01

ABA: GRA

ABS: The impact of water pollution control regulations, such as those outlined in 1972 FwPCA Amendments, on production costs in the electric utility industry are examined. The use of water by electric utilities, and the impact that water regulations will have on those uses are discussed. The production process of electric utilities is discussed, and a cost function from a cross-section sample of utility plants for the year 1973 is empirically estimated. It is this cost function which allows the evaluation the impact of increased regulation on the cost of production.



78A53047 ISSUE 24 PAGE 4395 CATEGORY 45  
78/10/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Sulfur control in coal fired power plants - A probabilistic approach to policy analysis

AUTH: A/MORGAN, M. G.; B/RISH, W. R.; C/MORRIS, S. C.; D/MEIER, A. K. PAA: B/(Carnegie-Mellon University, Pittsburgh, Pa.); C/(Brookhaven National Laboratory, Upton, N.Y.); D/(California, University, Berkeley, Calif.)

Air Pollution Control Association, Journal, vol. 28, Oct. 1978, p. 993-997. Research supported by the Alfred P. Sloan Foundation, MPC Corp., and ERDA.

MAJS: /\*AIR POLLUTION/\*COAL UTILIZATION/\*ELECTRIC POWER PLANTS/\*POLLUTION CONTROL/\*REMOVAL/\*SULFUR DIOXIDES  
MINS: / COST ANALYSIS/ INDUSTRIAL WASTES/ MORTALITY/ PENNSYLVANIA

ABA: S.D.

ABS: Economists have long argued that the optimum level of sulfur pollution control for a coal-fired power plant is that level which minimizes the sum of societal costs and pollution control costs. A probabilistic analytical technique is described for quantitative characterization of uncertainty in estimating both costs relative to a hypothetical 1000-Mwe plant located near Pittsburgh, Pennsylvania. The objective is to use subjective mortality estimates for developing an estimate of the level to which sulfur emissions from coal-fired power plants should be controlled. The analysis considers only mortality effects within a range of 80 km from the plant. Local morbidity effects, material damage and other direct economic losses, mortality and morbidity effects from long-range transport, and esthetic and ecological effects are neglected. Hence, any conclusions about appropriate control levels drawn from the results obtained must be interpreted as providing a lower-bound estimate of the true optimal level of control. Implications are discussed for policy based on alternative sets of values and assumptions.

79N18367# ISSUE 9 PAGE 1147 CATEGORY 44  
78/10/00 18 PAGES UNCLASSIFIED DOCUMENT

UTTL: Integrated assessment of electricity utility systems

AUTH: A/CHOR, P. M.; B/LARGE, D. B.; C/NIEMANN, B. L.; D/VAHORN, A. J.; E/SMITH, L. F. PAA:

E/(Environmental Protection Agency, Washington, D. C.)  
CORP: Teknekron, Inc., Berkeley, Calif. AVAIL. NTIS SAP: HC A12/MF A01

In Automation Industries, Inc. Energy/Environment 3  
p 353-370 (SEE N79-18352 09-42)

ABA: G.Y.

ABS: As a significant energy supplier, consumer of primary fuels, and producer of wastes and emission to air, water, and land, the electric utility industry through its investment and operating decisions influence the national economy and the environment. In turn, utility decisions are influenced by various factors: government energy and environmental policies, economic conditions, and technological considerations. A framework for assessing in an integrated manner the impact of these factors on the future investment and operating decisions made by utility firms was developed and is discussed.

79N24543# ISSUE 15 PAGE 2013 CATEGORY 45 RPT#:  
PB-290473/8 EPA-600/7-78-205 CNT#: EPA-R-804829  
78/10/00 60 PAGES UNCLASSIFIED DOCUMENT

UTTL: Balloon-borne particulate sampling for monitoring power plant emissions TLSP: Final Report, Nov. 1976 - Jul. 1978

AUTH: A/ARMSTRONG, J. A.; B/RUSSELL, P. A.; C/WILLIAMS, R. E.

CORP: Denver Research Inst., Colo. AVAIL. NTIS SAP: HC A04/MF A01

MAJS: /\*AIR POLLUTION/\*ELECTRIC POWER PLANTS/\*PARTICULATE SAMPLING/\*POLLUTION MONITORING/\*SAMPLERS

MINS: / BALLOON-BORNE INSTRUMENTS/ CHEMICAL ANALYSIS/ FOSSIL FUELS/ GAS ANALYSIS/ INDUSTRIAL WASTES/ REMOTE SENSORS

ABA: GRA

ABS: A light weight remote-controlled sensor sampler, carried aloft by a tethered balloon, that was developed to collect particulates from the plumes of fossil fuel power plants at various downwind distances, is presented. The airborne sampler is controlled from the ground by a radio transmitter and receiver/servo system. The sampler system was field tested at two sites burning low-sulfur coal, an urban and a rural power plant. The collected samples were analyzed in terms of size, concentration, and composition using scanning electron microscopy/energy dispersive X-ray spectrometry. In general, the particles were spheres with diameters less than 5 micrometers. Some agglomerates were found. Most of the fly ash was composed of Si and Al, with small amounts of Fe.



79A18013 ISSUE 5 PAGE 875 CATEGORY 45 CNT#:  
EY-76-C-06-1830 78/12/15 3 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Ozone formation related to power plant emissions  
AUTH: A/MILLER, D. F.; B/ALKEZWEENY, A. J.; C/HALES, J. M.  
: D/LEE, R. N. FAA: A/(Battelle Columbus  
Laboratories, Columbus, Ohio); D/(Battelle Pacific  
Northwest Laboratories, Richland, Wash.)  
Science, vol. 202, Dec. 15, 1978, p. 1186-1188.

MAJS: /\*AIR POLLUTION/\*ATMOSPHERIC CHEMISTRY/\*ELECTRIC POWER  
PLANTS/\*OZONE/\*PLUMES

MINS: / ENVIRONMENT SIMULATION/ PHOTOCHEMICAL REACTIONS/  
POLLUTION MONITORING

ABA: P.T.H.

ABS: An explanation for the excess ozone that has been  
reported in some power plant plumes is proposed,  
according to which the formation of excess ozone in  
plumes is consistent with conventional mechanisms of  
atmospheric chemistry, but subject to certain  
atmospheric conditions. Data were collected by  
aircraft on the average ozone trends in a plume and  
the ambient air as a function of plume age. The  
photochemistry of the background air was modeled and  
the average NOx and SO2 concentrations of plume were  
introduced into the reacting background. This  
simulation yielded a prediction of excess O3 formation  
in accord with observed data. For excess O3 formation  
it appears that conditions must be optimal for intense  
photochemical activity, and the plume must remain  
intact.

79N29688# ISSUE 20 PAGE 2701 CATEGORY 45 RPT#:  
PB-293804/1 PPSP/CEIR-2 78/11/00 324 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Power plant cumulative environmental impact report  
TLSP: Final Report

CORP: Maryland Dept. of Natural Resources, Annapolis, CSS:  
(Power Plant Siting Program.) AVAIL NTIS SAP: MC  
A14/MF A01

Sponsored in part by Md. Dept. of Health and Mental  
Hygiene, Md. Dept. of Econ. and Community Develop.,  
Md. Dept. of State Planning, and Md. Public Serv.  
Comm.

MAJS: /\*AIR POLLUTION/\*ELECTRIC POWER PLANTS/\*ENVIRONMENT  
POLLUTION/\*ENVIRONMENTAL SURVEYS/\*WATER POLLUTION

MINS: / AIR QUALITY/ COMBUSTION PRODUCTS/ ENVIRONMENT  
EFFECTS/ INDUSTRIAL WASTES/ MARYLAND/ RECOMMENDATIONS/  
REGULATIONS

ABA: GRA

ABS: The results of studies within the state of Maryland on  
the environmental effects of power plants are  
reported. Topics covered are energy and electric power  
supply, air quality, aquatic impact, radiological  
effects, socioeconomic impacts, transmission lines,  
groundwater usage, and cooling towers. Recommendations  
are made for legislation and/or changes in state  
policy as a result of the review.

## FOSSIL FUEL: FUTURE SHOCK?

John Gribbin

New Scientist, Vol. 79, No. 1117, August 24,  
1978, p. 541-543.

### Dr John Gribbin

is a researcher in the  
Science Policy  
Research Unit, the  
University of Sussex

The impact of carbon dioxide from  
burning fossil fuel on the climate  
of the Earth has become a major  
focus of scientific attention, with  
the publication of a US National  
Academy of Sciences report *Energy  
and Climate* (see *New Scientist*, vol 75, p 211) last year and  
papers appearing almost weekly in the socialist journals.  
Put at its simplest, the argument holds that burning fossil  
fuels (oil, coal, and gas) releases carbon dioxide into  
the atmosphere; carbon dioxide, through the "greenhouse  
effect", warms the surface of the Earth by retaining heat  
that would otherwise escape from the lower atmosphere. If  
the argument is valid, we must ask how much fossil fuel  
can we burn before a long-lasting and damaging climate  
shift becomes established?

78N13645# ISSUE 4 PAGE 510 CATEGORY 45 RPT#:  
EPRI-EA-418 CNT#: NSF AEN-75-15168 PROJ. 487-1  
77/04/00 51 PAGES UNCLASSIFIED DOCUMENT

UTTL: Time-variable air pollutant emission strategies for  
individual power plants TLSP: Final Report

AUTH: A/HILST, G. R.; B/LONDERGAN, R. J.; C/HOPPER, T. G.  
CORP: Research Corp. of New England, Wetherfield, Conn.  
AVAIL NTIS SAP: HC A04/MF A01

MAJS: /\*AIR POLLUTION/\*CONTAMINANTS/\*ELECTRIC POWER PLANTS/\*  
FOSSIL FUELS

MINS: / AIR QUALITY/ ENVIRONMENT PROTECTION/ STANDARDS/  
SULFUR DIOXIDES

ABA: ERA

ABS: A basis is provided for the evaluation of the  
feasibility, operational characteristics, and  
potential cost savings of sophisticated time-variable  
emissions control systems. Emphasis is on SO2  
emissions from a fossil-fuel power plant. The study  
utilizes two years of data from a site in the Northern  
Great Plains region. The data are applied to models  
for defining and evaluating time histories of  
pollutant emissions which satisfy all relevant air  
quality standards and minimize the operational costs  
of emissions control. Under conservative assumptions  
as to plant size, effective stack height, the  
potential for significant cost savings is shown  
through the use of time variable emissions control  
systems.

78A25447# ISSUE 9 PAGE 1613 CATEGORY 45 RPT#:  
APCA PAPER 77-56.4 77/06/00 22 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Technical and economic impacts of the application of  
environmental control technology options  
AUTH: A/HOUGLAND, E. S.; B/COCKRUM, L. S.; C/HOLLINDEN, G.  
A.; D/WELLS, W. L.; E/MASSEY, C. L. PAA:  
E/(Tennessee Valley Authority, Chattanooga, Tenn.)  
Air Pollution Control Association, Annual Meeting,  
70th, Toronto, Canada, June 20-24, 1977. 22 p.  
MAJS: /\*AIR POLLUTION/\*ECONOMIC IMPACT/\*ELECTRIC POWER  
PLANTS/\*ENVIRONMENTAL ENGINEERING/\*POLLUTION CONTROL/\*  
TECHNOLOGY ASSESSMENT  
MINS: / AEROSOLS/ COAL UTILIZATION/ DESULFURIZING/ ELECTRIC  
POWER SUPPLIES/ ELECTROSTATIC PRECIPITATORS/ EXHAUST  
GASES/ FLUID FILTERS/ NITROGEN OXIDES/ SCRUBBERS/  
SULFUR DIOXIDES

ABA: M.L.

ABS: The paper describes the current state of the art for  
SO<sub>2</sub>, NO<sub>x</sub>, and particulate control technology and the  
impacts of their application. Lime/limestone  
scrubbing, the most widely applied flue gas  
desulfurization process, is discussed, and double  
alkali scrubbing systems and recover systems are also  
considered. Lists of users of these desulfurization  
techniques are provided. Combustion modification  
procedures utilized to reduce NO<sub>x</sub> are examined with  
attention to load reduction, excess air, biased  
firing, flue gas recirculation, and burner  
modifications. Particulate control techniques that  
might supersede electrostatic precipitators are  
described; these include the use of a high-intensity  
ionizer as a precharger to the precipitator, chemical  
additives injected to reduce the resistivity of fly  
ash, hot-side precipitators to ameliorate ash  
resistivity problems, baghouses with special coated  
fabric filters, and wet scrubbers.

ORIGINAL PAGE IS  
OF POOR QUALITY

TU  
163.25  
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N38  
1977  
National Research Council, Committee on  
Energy and the Environment.  
Implications of environmental regulations  
for energy production and consumption: a  
report to the U.S. Environmental Protection  
Agency from the Committee on Energy and the  
Environment, Commission on Natural Resources,  
National Research Council. — Washington:  
National Academy of Sciences, 1977.  
xvi, 233 p. : ill. ; 23 cm. — (Analytical  
studies for the U.S. Environmental Protec-  
tion Agency ; v. 6)

78A25406 ISSUE 9 PAGE 1609 CATEGORY 45 RPT#:  
APCA PAPER 77-15.1 CONF-77002-5 77/06/00 24 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Character and transformation of pollutants from major  
fossil-fuel energy sources  
AUTH: A/SHRINER, D. S.; B/MCLAUGHLIN, S. B.; C/BAES, C. F.  
PAA: C/(Oak Ridge National Laboratory, Oak Ridge,  
Tenn.)  
Air Pollution Control Association, Annual Meeting,  
70th, Toronto, Canada, June 20-24, 1977. 24 p.  
MAJS: /\*AIR POLLUTION/\*COAL UTILIZATION/\*COMBUSTION PRODUCTS  
/\*ELECTRIC POWER PLANTS/\*NITROGEN OXIDES/\*SULFUR  
OXIDES  
MINS: / ATMOSPHERIC CHEMISTRY/ ATMOSPHERIC DIFFUSION/  
METEOROLOGICAL PARAMETERS/ SPATIAL DISTRIBUTION

ABA: G.R.

ABS: The physical and chemical characteristics of effluents  
from the stacks of a fossil-fuel energy source depend  
on source and fuel variables. An investigation is  
conducted concerning the potential significance of the  
more important of these variables in the  
transformation of effluents during the transport from  
the source. Compared to emissions from all sources,  
total estimated emissions from fuel combustion for  
electricity generation account for approximately 1% of  
the carbon monoxide, 25% of the particulates, 60% of  
the sulfur oxides, 25% of the nitrogen oxides, and 5%  
of the hydrocarbons. The high density of electric  
power plants in the East of the U.S. combined with  
high emissions from urban and industrial sources makes  
the widespread occurrence of potentially phytotoxic  
levels of combinations of pollutants particularly  
likely within this region. Attention is given to  
source-related emission trends, the spatial  
distribution of sources, regional meteorological  
factors affecting pollutant transport, and chemical  
characteristics affecting pollutant transport.

TA  
168  
.I52  
1977  
International Conference on Cybernetics  
and Society, Washington, D.C., 1977.  
Proceedings / sponsored by: IEEE Systems,  
Man and Cybernetics Society with the coopera-  
tion of: College of American Pathologists  
Coal Utilization and Environmental Control Tech-  
nology Assessment, George C. Ferrell, Interna-  
tional Institute for Applied Systems Analysis,  
Laxenburg, Austria 245  
The Energy-Environment Crisis, Charles E. Bond,  
University of Illinois, Urbana 350

TJ Greater Los Angeles Area Energy Symposium,  
163.2 1977.  
.G74 Greater Los Angeles Area Energy Symposium:  
1977 Tuesday, April 26, 1977 ... Los Angeles,

Environmental Assessments of New Fossil Energy Technologies  
for Electric Utilities  
Kenneth J. Heitner, TRW Energy Systems Group 127

Evaluation of Social and Economic Effects of Energy Facility,  
Construction and Operation.  
Michael H. Waklin, Bechtel Power Corp.;  
Brent P. Sherefy, Bechtel Corp. 128

Modeling the Impact of Air Pollution Control Strategies  
Gegory J. McRae, Environmental Quality Laboratory,  
California Institute of Technology 128

78A25399 ISSUE 9 PAGE 1635 CATEGORY 47 RPT#:  
APCA PAPER 77-58.5 77/06/00 16 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Critical wind speeds for buoyant sources of air  
pollution

AUTH: A/PUTTA, S. N. PAA: A/(Public Service Commission,  
Albany, N.Y.)  
Air Pollution Control Association, Annual Meeting,  
70th, Toronto, Canada, June 20-24, 1977. 16 p.

MAJS: /\*AIR POLLUTION/\*BUOYANCY/\*CRITICAL VELOCITY/\*ELECTRIC  
POWER PLANTS/\*WIND VELOCITY

MINS: / AIR QUALITY/ ATMOSPHERIC CIRCULATION/ METEOROLOGICAL  
PARAMETERS/ REGIONAL PLANNING/ SITES

ABA: M.L.

ABS: The paper derives explicit mathematical relationships  
for determining the critical wind speeds responsible  
for the peak ground level concentrations of air  
pollutants released from tall stacks. Basic equations  
for plume rise and diffusion are solved for all  
atmospheric stability conditions excluding trapping  
and fumigation conditions, and the functional  
relationships for critical wind speeds are obtained in  
terms of meteorological and stack design parameters.  
Numerical values for critical wind speeds normalized  
by the stack buoyancy parameter and expressed as a  
function of downwind distance show that ground level  
concentrations at a given downwind distance peak at  
the critical wind speed. Procedures for calculating  
the maximum possible concentration, its location, and  
the critical wind speed are described.

TK  
2896  
.I55  
1977

V.I

Intersociety Energy Conversion Engineering  
Conference, 12th, Washington, 1977.

Proceedings of the 12th Intersociety  
Energy Conversion Engineering Conference,

779095 — Improved Systems for Energy Conver-  
sion and Conservation as Pollution Control Al-  
ternatives—U.S.EPA Program, H. E. Bostian, H.  
S. Skovronek, R. E. Mourninghan, U.S. Environ.  
Prot. Agency, Cincinnati, O. .... 600

779096 — Pollution Control in Geothermal En-  
ergy, R. P. Hartley, U.S. Environ. Prot. Agency,  
Cincinnati, O. .... 607

779097 — Environmental Impact of Major Solar  
Energy Development, D. R. Sears, M. G. Gandel,  
Lockheed, Huntsville, Ala.; R. P. Hartley, U.S.  
Environ. Prot. Agency, Cincinnati, O.; W. G.  
Bradley, Environ. Consultants, Inc. .... 614

779098 — Environmental, Economic and Conser-  
vation Aspects of Integrated Energy Systems, N.  
B. Hilsen, G. R. Fletcher, R. D. Wilkins, J. S.  
Tiller, Georgia Inst. of Tech., Atlanta, Ga.; C.  
C. Lee, U.S. Environ. Prot. Agency, Cincinnati,  
O. .... 621

779099 — The Air Quality Implications of the  
Move Toward Coal, R. D. Bauman, J. D. Cren-  
shaw, U.S. Environ. Prot. Agency .... 629

779100 — The Impact of Air Quality Regulations  
on the Electric Power Industry, K. E. Yeager,  
Electric Power Res. Inst., Palo Alto, Calif. .... 637



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1977

V.1

**Intersociety Energy Conversion Engineering  
Conference, 12th, Washington, 1977.**

**Proceedings of the 12th Intersociety  
Energy Conversion Engineering Conference,**

- 779101 — **Development Status and Environmental  
Hazards of Several Candidate Advanced Energy  
Systems**, M. M. Penny, S. V. Bourgeois, Lock-  
heed, Huntsville, Ala.; W. C. Cain, U.S. Environ.  
Prot. Agency, Cincinnati, O. .... 646
- 779102 — **Environmental Considerations in Ad-  
vanced Energy Conversion Technology Assess-  
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Linden, N.J.; W. C. Cain, U.S. Environ. Prot.  
Agency, Cincinnati, O. .... 655
- 779103 — **Environmental Assessment of Advanced  
Energy Conversion Technologies**, A. D. Car-  
michael, J. F. Louis, J. D. Teare, S. E. Tung,  
Massachusetts Inst. of Tech., Cambridge, Mass. 662
- 779104 — **A Comparison of the Environmental Im-  
pact of Conventional and Fluid Bed Boilers in  
Advanced Steam Power Plants**, C. E. Jahnig, H.  
Shaw, Exxon Research & Eng. Co., Linden, N.J. 670
- 779105 — **An Environmental Assessment of Li-  
quid Metal Topping Cycles**, C. E. Jahnig, H.  
Shaw, Exxon Research & Eng. Co., Linden, N.J. 675
- 779106 — **An Environmental Assessment of a 638  
MW Molten Carbonate Fuel Cell Power Plant**,  
C. D. Kalfadelis, G. Ciprios, H. H. Horowitz, H.  
Shaw, Exxon Research & Eng. Co., Linden, N.J. 681

**AIR POLLUTION ASSESSMENTS OF NEW FOSSIL  
ENERGY TECHNOLOGIES**

Kenneth L. Heitner

Air Pollution Control

Vol. 27 no. 12 Dec. 1977

p. 1173-1177

This paper presents an overview on air pollution assessments of new fossil energy technologies for baseload electric generating plants. The discussion is oriented towards those who must understand the broad issues affecting the design and performance of such power plants. It is motivated by the potential air pollution problems caused by the near doubling of coal use projected for the next 15 years.

The paper first reviews the applicable emissions performance standards for these plants, as well as predictions of likely future standards needed to protect the environment. The conclusion is reached that significantly tighter emissions standards will apply in the future.

Next, the cost, emissions performance, and development status of the three major technology groups for coal fired baseload plants are reviewed.

77A38121 ISSUE 17 PAGE 2913 CATEGORY 45  
77/07/00 8 PAGES UNCLASSIFIED DOCUMENT  
UTTL: An application of the economic-environmental power  
dispatch --- decision approach for controlling air  
pollution emission from electric power generation  
AUTH: A/ZAHAVI, J.; B/EISENBERG, I. PAA: A/(Tel Aviv  
University, Tel Aviv, Israel); B/(Pennsylvania  
University, Philadelphia, Pa.)  
IEEE Transactions on Systems, Man, and Cybernetics,  
vol. SMC-7, July 1977, p. 523-530.  
MAJS: /\*AIR POLLUTION/\*DECISION MAKING/\*ELECTRIC POWER  
PLANTS/\*ENVIRONMENT PROTECTION/\*EXHAUST GASES/\*  
POLLUTION CONTROL  
MINS: / COAL UTILIZATION/ COMBUSTION PRODUCTS/ COST  
EFFECTIVENESS/ ENERGY TECHNOLOGY/ FUEL OILS/ GAS  
TURBINE ENGINES/ SYSTEMS ENGINEERING  
ABA: (Author)  
ABS: An application of a decision approach for controlling  
air pollution emission from power generation is  
described. Trade-off curves between pollution emission  
and total operating cost are first computed for a  
portion of a realistic system containing coal, oil,  
and gas turbine generation. Points on the trade-off  
curve are then mapped into an exposure measure by  
using an air pollution diffusion model for the region  
being analyzed. The computations were carried out for  
several demand levels and various weather conditions.  
A comparative analysis of the results and their  
implications to power dispatch decisions are  
discussed.

GC The Fate of fossil fuel CO<sub>2</sub> in the oceans /  
 117 edited by Neil R. Andersen and Alexander  
 .C37 Malapoff. -- New York : Plenum Press, c1977.  
 F37 xii, 749 p. : ill. ; 26 cm. — (Marine  
 science ; v. 6)

"Proceedings of a symposium conducted by  
 the Ocean Science and Technology Division of  
 the Office of Naval Research ... held at the  
 University of Hawaii, Honolulu, January 16-  
 20, 1976."

Includes bibliographies and  
 index.

Public Utilities Fortnightly, v.100,  
 no.7

Sept.29,  
 1977

Fossil Projects Need Siting Help Too ..... David Myhra 24

A narrative history of one of the largest projected electric generating  
 plants to have been abandoned before construction, with an analysis of  
 the factors leading to its abandonment and their significance for the na-  
 tion's energy future.

78N17514# ISSUE 8 PAGE 1041 CATEGORY 45 RPT#:  
 PB-274120/5 77/10/00 35 PAGES UNCLASSIFIED  
 DOCUMENT

UTTL: Electric utilities use of flue gas desulfurization  
 technology in the United States

AUTH: A/DASTI, A. Q.  
 CORP: Federal Energy Regulatory Commission, Washington, D.  
 C. AVAIL:NTIS SAP: HC A03/MF A01

MAJS: /\*AIR POLLUTION/\*DESULFURIZING/\*ELECTRIC POWER PLANTS  
 MINS: / COAL UTILIZATION/ COMBUSTION PRODUCTS/ ELECTROSTATIC  
 PRECIPITATORS/ INDUSTRIAL WASTES

ABA: GRA  
 ABS: Flue gas desulfurization units in the planning stage,  
 under construction and in operation were identified,  
 according to geographical location.

79N71299# CATEGORY 45 RPT#: ANL/ECT-3-APR-G  
 CNT#: W-31-109-ENG-38 77/12/00 228 PAGES  
 UNCLASSIFIED DOCUMENT

UTTL: Environmental control implications of generating  
 electric power from coal, 1977 technology report.  
 Appendix G: State-of-the-art review and simultaneous  
 removal of nitrogen oxides and sulfur oxides from flue  
 gas TLSP: Status Report

AUTH: A/MAXWELL, J. D.; B/FAUCETT, H. L.; C/BURNETT, T. A.  
 CORP: Tennessee Valley Authority, Muscle Shoals, Ala.  
 AVAIL:NTIS

MAJS: /\*COAL UTILIZATION/\*COMBUSTION PRODUCTS/\*NITROGEN  
 OXIDES/\*POLLUTION CONTROL/\*SULFUR OXIDES/\*TECHNOLOGY  
 ASSESSMENT

MINS: / AIR POLLUTION/ DENITROGENATION/ DESULFURIZING/  
 ELECTRIC POWER PLANTS/ ENVIRONMENTAL CONTROL/ EXHAUST  
 GASES

AICHE Symposium Series, v.73, no.165

1977

DISPERSION AND CONTROL OF ATMOSPHERIC EMISSIONS:  
 NEW-ENERGY-SOURCE POLLUTION POTENTIAL.  
 R. Lee Byers, Burton B. Crocker, and Douglas W.  
 Cooper, eds.

American Institute of Chemical Engineers

*Continued next page*



## AIR POLLUTION POTENTIAL OF NEW ENERGY SOURCES

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## ELECTRIC POWER ENGINEERING - POWER TRANSMISSION

THE LASER FUTURE, by Edward T. Gerry and John D.G. Rather.  
Astronautics & Aeronautics, vol. 17, no. 3, March 1979,  
p.60-67.

HIGH-POWER LASER APPLICATIONS, by Abraham Hertzberg and Kenneth W. Billman.  
Astronautics & Aeronautics, vol. 17, no. 3, March 1979,  
p.16-17.

SOLAR POWER SATELLITES: THE LASER OPTION, by Wayne S. Jones and Maxwell W. Hunter II.  
Astronautics & Aeronautics, vol. 17, no. 3, March 1979,  
pg.59- con't on p. 67.

POWER FROM SPACE BY LASER, by Claud N. Bain.  
Astronautics & Aeronautics, vol. 17, no. 3, March 1979,  
p.28-40.

Lasers can deliver energy collected by a solar-power satellite, and the field is beginning to move to produce the technology for doing this for reasonable weight and cost.

TL  
507  
.P75  
v.61

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NASA Conference on Radiation Energy Conversion, 3d, Ames Research Center, 1979.  
Radiation energy conversion in space...  
cl978

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Status and Summary of Laser Energy Conversion GEORGE LEE	549

TA Adaptive optical components...cl 1978.  
1522 ISEN 0-89252-168-6.

.A43 1. Optics, Adaptive—Congresses. I. Holiv.

141-18 Ground-to-Space Optical Power Transfer... *P.108-117* .....108

G. E. Mevers, C. L. Hayes, J. F. SooHoo, and R. M. Stubbs, Rockwell International

Using laser radiation as the energy input to a rocket, it is possible to consider the transfer of large payloads economically between low initial orbits and higher energy orbits. In this paper we will discuss the results of an investigation to use a ground-based High Energy Laser (HEL) coupled to an adaptive antenna to transmit multi-megawatts of power to a satellite in low-earth orbit. Our investigation included diffraction effects, atmospheric transmission efficiency, adaptive compensation for atmospheric turbulence effects, including the servo bandwidth requirements for this correction, and the adaptive compensation for thermal blooming. For these evaluations we developed vertical profile models of atmospheric absorption, strength of optical turbulence ( $C_N^2$ ), wind, temperature, and other parameters necessary to calculate system performance. Our atmospheric investigations were performed for  $CO_2$ ,  $^{12}C^{18}O_2$  isotope, CO and DF wavelengths. For all of these considerations, output antenna locations of both sea level and mountain top (3.5 km above sea level) were used.

NASA CP-2058 1978  
Power transmission, Laser

FUTURE ORBITAL POWER SYSTEMS TECHNOLOGY REQUIREMENTS.  
(Symposium held LeRC, May 31-June 1, 1978). Sept. 1978. 322p.

Symposium on Future Orbital Power May 31-June 1,  
Systems Technology Requirements 1978

LASER POWER TRANSMISSION FOR SPACE POWER AND PROPULSION  
Lott W. Brantley, NASA Marshall Space Flight Center p. 289

LASER/MICROWAVE TRANSMISSION WORKSHOP *p. 297*.

NASA CR-3044 1978  
Power transmission, Microwave  
RESEARCH PLAN FOR STUDY OF BIOLOGICAL AND ECOLOGICAL  
EFFECTS OF THE SOLAR POWER SATELLITE TRANSMISSION  
SYSTEM. Bernard D. Newson. Aug. 1978. 354p.

Newson (Bernard D.),  
Los Altos Hills, Calif.

CI-150,011 1978  
SOLAR POWER SATELLITE. (Hearings before the Subcommittee  
on Space Science and Applications and the Subcommittee on  
Advanced Energy Technologies and Energy Conservation  
Research, Development and Demonstration of the Committee  
on Science and Technology, U.S. House of Representatives,  
95th Congress, 2nd Session, Apr. 12-14, 1976). 1976. 450p

95th Congress, 2nd Session  
95th Congress, 2nd Session No. 63  
Committee on Science and Technology

Compilation and assessment of microwave bioeffects  
of the satellite power system. p. 118-  
R.D. Phillips.

Compilation and assessment of microwave bioeffects.  
D.R. Justesen. p. 135-

This report, "A Selective Review of the Literature on Biological  
Effects of Microwaves in Relation to the Satellite Power System," is the  
first of two documents prepared for the Department of Energy under a  
contract for Compilation and Assessment of Microwave Bioeffects. The  
second document, "An Outline of SPS Research Needs and Study Plan," is  
published separately but is developed in consequence of data and problem  
areas identified in the Selective Review.



NEW DEVELOPMENTS IN ELECTROMAGNETIC ENERGY BEAMING.  
E.J. Nalos.  
IEEE Proceedings, v.66, no.3, Mar.1978, p.276-289.

**Abstract**—Current developments in large-aperture antennas coupled with the projected performance of high-power electron beam and solid-state devices for generation and rectification purposes, make it possible to greatly extend present capabilities of microwave/millimeter-wave beaming systems. These include greatly enhanced radar performance as well as some totally new applications of energy beaming. These extend over a large range of energy densities, all the way from  $10^{-10}$  W/cm<sup>2</sup> typical of receiver sensitivities, to energy densities in excess of  $10^3$  W/cm<sup>2</sup> adequate for thermal interaction with many materials. This paper attempts to summarize some of the technology trends which support these applications, particularly in the areas of short range surveillance, space-space beaming, and some long range applications such as space based illumination. Some comparisons are also made with laser beaming, indicating the possible complementary use of both types of devices.

IONOSPHERIC HEATING BY RADIO WAVES: PREDICTIONS FOR  
ARECIBO AND THE SATELLITE POWER STATION.  
F.W. Perkins and R.G. Roble.  
J.Geophys.Res., v.83, no.A4, Apr.1,1978, p.1611-

The effect of resistive heating by radio waves on ionospheric temperatures, electron densities, and airglow emissions is examined by using numerical ionospheric structure and heat balance codes. Two cases are studied: (1) a 3-GHz, 10-GW microwave beam from a proposed satellite power station and (2) 1-MW and 3-MW beams of 15-MHz radio waves launched by the Arecibo antenna. By intent, these two cases have similar intensities and geometries of resistive heating. The most dramatic heating effects are predicted to occur in the E region, where a thermal runaway will take place. The E region electron temperature will increase from 200°K to roughly 1000°K, and the E region electron density will increase by a factor of about 3. In the F region, where thermal conductivity plays an important role, temperature increases of 200°-500°K will appear along magnetic field lines passing through the radio wave beams. Enhanced emissions in airglow and molecular infrared lines will also occur. Radio wave heating, when combined with the diagnostic capabilities of the Arecibo incoherent scatter radar, will generate new opportunities to measure the rates of atomic physics processes and neutral atmosphere temperatures and composition at D and E region altitudes.

THE REEMERGENCE OF DC IN MODERN POWER SYSTEMS.  
EPRI Journal, June 1978, p.6-13.

For the first time in the history of electric utilities, ac and dc have important and complementary roles to play.

TA  
403  
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Critical materials problems in energy production / edited by Charles Stein. --  
New York : Academic Press, 1976.  
xii, 915 p. : ill. ; 25 cm.

"This volume is the result of a series of distinguished lectures sponsored by the Joint Center for Materials Science in New Mexico."

## II. ENERGY TRANSMISSION

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HIGH VOLTAGE DC TRANSMISSION APPLICATIONS OFFSHORE  
Lars A. Bergstrom and Kjell Eriksson  
IEEE Transactions on Industry Applications, v.1A-14,  
no.2, March/April 1978, pp.183-187

**Abstract**—An offshore power plant and high voltage dc (HVDC) transmission to bring the generated energy ashore are described. Off-shore gas fields will, in some cases, be better utilized if the gas can be burned in platform located gas turbines to generate electric power which is transmitted to shore via HVDC cable circuits. The proposed system should be considered when the distance is long, the water depth is large, or the gas deposit is small.

TL  
797  
.P65  
1977  
Princeton/AIAA Conference on Space Manufacturing Facilities, 3d, Princeton, N.J., 1977.  
Space manufacturing facilities II : proceedings of the Third Princeton/AIAA Conference May 9-12, 1977 / edited by Jerry Grey. — New York : American Institute of Aeronautics and Astronautics, 1977.  
xi, 356 p. : ill.  
1. Space stations—Congresses. I. Grey, Jerry. II. American Institute of Aeronautics and Astronautics.

Microwave Energy Transmission/William C. Brown, Raytheon Corporation  
P.191-

N77-31813\* Raytheon Co., Wayland, Mass. Microwave and Power Tube Div.

**ELECTRONIC AND MECHANICAL IMPROVEMENT OF THE RECEIVING TERMINAL OF A FREE-SPACE MICROWAVE**

**POWER TRANSMISSION SYSTEM**

William C. Brown 1 Aug. 1977 158 p refs

(Contract NAS3-19722)

(NASA-CR-135194; PT-4964) Avail: NTIS HC A08/MF A01

CSCL 10A

Significant advancements were made in a number of areas: improved efficiency of basic receiving element at low power density levels, improved resolution and confidence in efficiency measurements mathematical modelling and computer simulation of the receiving element and the design, construction, and testing of an environmentally protected two-plane construction suitable for low-cost, highly automated construction of large receiving arrays. Author

Q Advances in instrumentation, v. 31, pts. 1-4;

184 proceedings of ISA Conference and Exhibit,

.A5 Houston, Texas, October 11-14, 1976. --

v.31 Pittsburgh : Instrument Society of America,  
pt.1-4 cl976.

4 v. : ill. ; 29 cm.

1. Scientific apparatus and instruments--  
Congresses. 2. Engineering instruments--  
Congresses. I. Instrument Society of America.  
ca. II. ISA Conference and Exhibit, Houston,

1076  
HIGH-POWER MICROWAVE TRANSMISSION FROM SOLAR  
SPACE STATIONS, G. D. Arndt and L. Leopold .PN-472.....

**TECHNOLOGICAL EVOLUTION IN TRANSMISSION SYSTEMS.**

W. Haas.

Electrical Communication, v.52, no.4, 1977, p.283-288.

The human race has always felt the need to exchange news over ever longer distances. The historical as well as technical means were either by courier, who carried a written message on foot or on horseback, or by fire and smoke signals, a method mainly used by the North American Indians. This was followed in 1790 by telecommunications networks based on semaphore and other optical communications systems such as heliographs. Even at that time the distinguishing features of a communications link were: length of the connection, communications capacity, quality, and speed. The start of the twentieth century brought a new era in transmission systems. First tests on carrier frequency telephone systems for 2 to 4 speech channels were made in 1926. In rapid succession new carrier frequency telephone systems were developed with ever increasing capacities. Even at this time the majority of the components used were of the electronic type; tubes, rectifiers, capacitors, resistors, and coil transformers. Electromechanical components were mainly used for adjustment and supervision.



XIII. AUTOMOTIVE POWERPLANTS . . . . .	1084
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## AUTOMOTIVE POWERPLANTS - GENERAL

79N29608\*# ISSUE 20 PAGE 2692 CATEGORY 44  
RPT#: NASA-CASE-LAR-12148-1 US-PATENT-APPL-SN-051275  
79/06/22 12 PAGES UNCLASSIFIED DOCUMENT

UTTL: Solar engine --- Flat plate type TLSP: Patent  
Application

AUTH: A/JENSEN, R. N. PAT: A/Inventor (to NASA)

CORP: National Aeronautics and Space Administration, Langley  
Research Center, Langley Station, Va. AVAIL:NTIS  
SAP: HC A02/MF A01

MAJS: /\*ENGINE DESIGN/\*FLAT PLATES/\*PISTON ENGINES/\*SOLAR  
ENERGY CONVERSION/\*THERMODYNAMIC CYCLES  
MINS: / DISPLACEMENT/ FLUID DYNAMICS/ HEAT TRANSFER/ PATENT  
APPLICATIONS/ SOLAR ENERGY ABSORBERS

ABA: NASA

ABS: A solar engine is disclosed in which a fluid, which is  
first heated and then cooled, forces a piston outward  
as the fluid is heated, and then draws inward as the  
fluid is cooled. The piston is connected to a shaft  
and produces work as it moves outward and inward. A  
displacer plate moves between an absorber plate and a  
cooling plate to form an air space between the  
displacer and one or the other of these two plates for  
heating and cooling the fluid. The displacer plate is  
for heating and cooling the fluid. The displacer plate  
is moved from one plate to the other by the displacer  
push ring as the piston nears the midpoint of its  
travel on the outward stroke and again on the inward  
stroke.

THE FUTURE OF THE AUTOMOBILE IN AN OIL-SHORT WORLD.  
L. R. Brown.

The Futurist, vol 13, no 6, December 1979, p. 447-458.

As oil supplies dwindle, the personal automobile will  
have to absorb the brunt of any future shortages.  
Unless major changes are made in the role and design  
of the automobile, people will be forced to turn to  
public transportation, two-wheeled vehicles, and  
walking.

TK  
2896  
.155  
1979

Intersociety Energy Conversion Engineering  
Conference, 14th, Boston, 1979.  
Proceedings of the 14th Intersociety  
Energy Conversion Engineering Conference,  
Boston, Massachusetts, August 5-10, 1979.  
-- Washington, D. C. : American Chemical  
Society, c1979.

### Heat Engines

799225  
The Effects of Mixture Strength Fluctuation  
on the Efficiency of Small Engines, K.S. Varde  
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G.J. Silvestri, R.M. Tompkins, D.A. Bowlus  
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The Osmo-Hydro Power™ Heat Engine: A  
Progress Report, S. Loeb, M.D. Fraser, S.C.  
Jain and G.D. Mehta ..... 1055

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Predicting the Performances of Marine Two-  
Stroke Compression Ignition Engines,  
B. Fortunato, M. Napolitano and A. Dadone .. 1061

THE AUTOMOBILE'S ENDANGERED FUTURE. R. P. Brennan.

Futurist, vol 13, no 5, October 1979, p. 317-323.

No modern technology is more vulnerable to scarcities of fossil fuels than the automobile, but technological innovations could bring radically new cars to America's highways.

#### DO WE HAVE A CHOICE?

Will Barron, Edwin Crawford, & Morton Weinberg

Automotive Engineering, Vol. 86, No. 7, July 1978, p. 26-31.

Do we have a choice of keeping the automobile, or will it gradually be driven to extinction by fuel shortages and other external forces? Yes, we have such a choice. That's the conclusion drawn from

a recent Maryland Department of Transportation survey which examined the potential for widespread mid- and long-term use of alternative power sources for automobiles and light trucks.

TJ  
762  
.S95  
Z5613

Zinner, K., 1905-

Supercharging of internal combustion engines : fundamentals, calculations, examples / K. Zinner ; translation from the German by G. Winkler. — Berlin ; New York : Springer-Verlag, 1978.  
x, 290 p. : ill.

Translation of Aufladung von Verbrennungsmotoren.

Bibliography: p. 276-285.

ISBN 0-387-08544-0

1. Super- chargers. I. Title.

79A12980# ISSUE 3 PAGE 409 CATEGORY 44  
78/00/00 42 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Alternative fuels for reciprocating internal combustion engines  
AUTH: A/GALLOPOULOS, N. E. PAA: A/(GM Research Laboratories, Warren, Mich.)  
In: Alternative hydrocarbon fuels: Combustion and chemical kinetics: SQUID workshop, Columbia, Md., September 7-9, 1977. Technical Papers. (A79-12977 03-25) New York, American Institute of Aeronautics and Astronautics, Inc., 1978. p. 74-112: Discussion. p. 112-115.

ABA: G.R.

ABS: By the year 2000 world petroleum demand will have outstripped supply. These circumstances compel the search for fuels not derived from petroleum, which usually are referred to as alternative fuels. Results of several investigations have shown that hydrogen-fueled Otto cycle engines are efficient because of hydrogen's high flame speed and because they can operate at very lean equivalence ratios. However, the low volumetric energy density of hydrogen makes its storage on vehicles a difficult problem to solve, particularly for passenger cars and other small vehicles. Compared to hydrocarbon fuels, ammonia combustion in normally aspirated Otto cycle engines yields very low efficiency and power. There are also ignition problems. Because of their similarity with current petroleum-derived fuels, many of the organic alternative fuels present fewer technical challenges than inorganic fuels. The greatest challenge presented by the organic alternative fuels for the near future is related to the technology and the economics of converting various natural resources to organic automotive fuels.

#### NEW SENSORS FOR AUTOMOBILE ENGINE CONTROL.

W.G. Wolber.

Instrumentation Technology, v.25, no.8, Aug.1978, p.47-53.

New sensors are nearing production for use in automotive engine control systems. The sensed parameters include absolute and differential pressure, contacting and noncontacting angle pickoffs, air and fuel flow, oxygen partial pressure and temperature. These sensors have moderate but long-term accuracy. Generally self-contained, they produce a high level output and can survive in a near military environment. Their mass production at low cost will produce major changes in the instrumentation industry.



A80-13199 Hydrogen-powered vs. battery-powered automobiles. J. J. Donnelly, Jr., W. C. Greayer, R. J. Nichols (Aerospace Corp., El Segundo, Calif.), W. J. D. Escher (Escher Technology Associates, St. Johns, Mich.), and E. E. Ecklund (U.S. Department of Energy, Washington, D.C.). *International Journal of Hydrogen Energy*, vol. 4, no. 5, 1979, p. 411-443. 33 refs.

Two future candidate automobile propulsion systems which do not rely upon petroleum or natural gas as an energy source have been studied and the resultant vehicle characteristics identified. The first vehicle system employs a gaseous hydrogen-fueled internal combustion engine (ICE) and either a liquid or metal hydride energy storage system. The second vehicle system employs an electronically controlled electric motor power train and a battery energy storage system. Major tasks included in this study were the technical and economic assessments of the state of the art and future alternatives in hydrogen production and delivery, the hydrogen vehicle assessment, the battery-electric vehicle assessment and the comparison of the principal vehicle alternative in 1985, 1990 and 2000. The comparison includes weight, size, cost, energy and design range relationships and the implications on expenditure of all major energy sources. The study is summarized, results presented and conclusions drawn. Comments are made on the future roles of hydrogen and electricity in automobile propulsion. (Author)

### Energy and Labor Cost of Gasoline Engine Remanufacturing by E.R. Venta & A.M. Wolsky

Argonne National Laboratory Report ANL/CNSV-1  
September 1978

This report presents a detailed estimate of the labor and energy, by fuel type, required by the U.S. economy to remanufacture gasoline-fueled automobile and truck engines. The estimate was obtained by combining data provided by several remanufacturers with the results of input-output analysis. A rough estimate of the labor and energy required to manufacture new engines is also given. These estimates suggest that remanufactured engines require 50% of the energy and 67% of the labor that new engines require.

### ALTERNATIVE AUTOMOBILE ENGINES.

David Gordon Wilson

Scientific American, Vol. 239, No. 1, July 1978,  
p. 39-49.

The propulsion systems most often mentioned as being potentially more promising than the spark-ignition (Otto) engine for meeting or exceeding the Federal requirements in regard to fuel economy and emissions are the compression-ignition (Diesel) engine, the steam (Rankine) engine, the gas turbine (Brayton engine), the Stirling engine and battery-electric drives. All have a potential for substantial improvement over their present state of development that would make them extremely attractive contenders for future mass production, although the battery-electric drive could have only a restricted duty. Perhaps the principal problems facing Government decision makers who want to encourage the development of an improved engine are the missionary fervor with which partisans back one particular engine and the oversimple criteria by which engines tend to be judged. The choice of a new engine is in fact extremely complex. After reviewing the advantages and disadvantages of the various candidate engines I shall suggest the kind of Government policy I believe most likely to identify, quickly and economically, the engine or engines (if any exist) that can supplant the 102-year-old invention of Nikolaus August Otto.



78N33526\* ISSUE 24 PAGE 3233 CATEGORY 44 RPT#:  
 NASA-CASE-NPO-13763-1 US-PATENT-4,112,875  
 US-PATENT-APPL-SN-718268 US-PATENT-CLASS-123-DIG.12  
 US-PATENT-CLASS-123-1A US-PATENT-CLASS-123-3  
 78/09/12 6 PAGES UNCLASSIFIED DOCUMENT  
 Filed 27 Aug. 1976 Supersedes N77-11398 (15 - 02, p  
 0200)

UTTL: Hydrogen-fueled engine TLSP: Patent  
 AUTH: A/LAUMAN, E. A.; B/REYNOLDS, R. K. PAA: A/(JPL);  
 B/(JPL) PAT: B/Inventors (to NASA)  
 CORP: National Aeronautics and Space Administration,  
 Pasadena Office, Calif.; Jet Propulsion Lab.,  
 California Inst. of Tech., Pasadena. SAP: Avail: US  
 Patent Office  
 Sponsored by NASA  
 MAJS: /\*ENERGY TECHNOLOGY/\*ENGINE DESIGN/\*HYDROGEN ENGINES/\*  
 INTERNAL COMBUSTION ENGINES  
 MINS: / ARGON/ ELECTROLYSIS/ EXHAUST GASES/ HYDROGEN  
 PRODUCTION/ PATENTS/ SOLAR CELLS  
 ABA: Official Gazette of the U.S. Patent Office  
 ABS: A hydrogen-oxygen fueled internal combustion engine is  
 described, which utilizes an inert gas, such as argon,  
 as a working fluid to increase the efficiency of the  
 engine, eliminate pollution, and facilitate operation  
 of a closed cycle energy system. In a system where  
 sunlight or other intermittent energy source is  
 available to separate hydrogen and oxygen from water,  
 the oxygen and inert gas are taken into a diesel  
 engine into which hydrogen is injected and ignited.  
 The exhaust is cooled so that it contains only water  
 and the inert gas. The inert gas in the exhaust is  
 returned to the engine for use with fresh oxygen,  
 while the water in the exhaust is returned to the  
 intermittent energy source for reconversion to  
 hydrogen and oxygen.

HOW DO ALTERNATIVE POWERPLANT COSTS COMPARE?  
 G. Mauri, G. Pl Fetterman, Jr., & R. L. Ricci  
 Automotive Engineering, Vol. 86, No. 5, May 1978,  
 p. 39 - 41

Government legislation and possible fuel shortages are  
 making total transportation cost factors increasingly  
 important. This article compares initial cost and operating  
 cost of four advanced automotive powerplants.

78A36445 ISSUE 15 PAGE 2760 CATEGORY 44  
 78/05/00 3 PAGES UNCLASSIFIED DOCUMENT

UTTL: Hydrogen fuel and its application to vehicular systems  
 AUTH: A/BILLINGS, R. E. PAA: A/(Billings Energy Corp.,  
 Provo, Utah)  
 Energy, vol. 3, Spring 1978, p. 28-30.  
 MAJS: /\*AUTOMOBILE FUELS/\*CRYOGENIC FLUID STORAGE/\*HYDROGEN/  
 FUELS  
 MINS: / AIR POLLUTION/ AUTOMOBILE ENGINES/ ECONOMIC ANALYSIS  
 / ENERGY TECHNOLOGY/ METAL HYDRIDES/ SAFETY FACTORS/  
 SYNTHETIC FUELS  
 ABA: M.L.  
 ABS: Some hydrogen storage systems for hydrogen-fuel  
 automobiles are surveyed, and the engine efficiency of  
 gasoline and hydrogen fuel automobiles is compared.  
 Advantages and disadvantages of iron-titanium hydride  
 and cryogenic hydrogen storage systems are examined.  
 safety tests of a metal hydride tank are reported, and  
 the lack of air pollution caused by hydrogen  
 combustion is noted. The operational economics of  
 hydrogen fuel use is considered with attention to the  
 efficiencies of generating synthetic hydrogen,  
 methanol, gasoline, and electricity from coal. It is  
 suggested that a taxi fleet could be used to test the  
 application of hydrogen as a vehicular fuel sometime  
 during the 1980-1985 period.

AN OTTO FOR THE AUTOMOBILE. PART II  
 Arnold W. Reitze, Jr.

Environment, vol. 19, no. 4, May 1977, page 32-42.

Cars powered by new machines which whine, whoosh,  
 or whirl periodically pass their counterparts powered  
 by conventional internal-combustion engines. But in  
 the long run the latter devices appear likely to win  
 the race for acceptable power plants. Part II of  
 Environment's series on the future of the automobile.

UTTL: Alternative automotive engines and energy conservation  
AUTH: A/LINDEN, L. H.  
CORP: Massachusetts Inst. of Tech., Cambridge. AVAIL NTIS  
SAP: HC A24/MF A01  
In Union Coll. Effects of Energy Constraints on  
Transportation Systems p 81-114 (SEE N78-18529 09-44)  
Repr. from Energy and Transportation, SAE-SP-406, Feb.  
1976  
MAJS: /\*AUTOMOBILES/\*ENERGY CONSERVATION/\*INTERNAL  
COMBUSTION ENGINES  
MINS: / ENERGY POLICY/ ENGINE DESIGN/ FUEL CONSUMPTION/  
TRANSPORTATION

ABA: Author

ABS: While substantial savings can be expected in  
automobile energy consumption, the contributions  
towards these savings from alternative engines is not  
clear. Two issues are discussed: one pertains to  
uncertainties in current estimates of the benefits to  
be gained from alternative power-plants, and the other  
pertains to uncertainties in the role of the  
automobile in the industry's process of technological  
innovation. Thus, while the case was made that some of  
the more promising alternative engines offered the  
potential for significant savings in automotive fuel  
consumption, and were therefore options worth  
pursuing, the case was also made that these savings  
might be realized without the introduction of  
alternatives and the upheaval such introduction would  
bring.

✓ 78N33592# ISSUE 24 PAGE 3241 CATEGORY 44 RPT#:  
COO-4248-1 CNT#: EC-77-C-02-4248 77/11/00 25  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Passenger car fuel economy in short trip operation  
TLSP: Technical Progress Report, 1 May 1977 - 30 Nov.  
1977

AUTH: A/PHOEBE, C. H.

CORP: Gulf Research and Development Co., Pittsburgh, Pa.  
AVAIL NTIS SAP: HC A02/MF A01

ABA: ERA

ABS: A program is described to provide a base line for  
studies of short-trip fuel economy that will  
eventually be needed to evaluate alternative power  
plants and fuels. Objectives are: the evaluation of  
methods devised to provide fuel utilization, and  
comparison of conventional gasoline with a special  
fuel blend aimed at improved short-trip economy. The  
test design, selection of the fuel blends, driving  
cycle, operating procedure, test equipment, selection  
of the test vehicles, and data handling methods are  
outlined. Fuel consumption measurements were made on  
four vehicles operated on a chassis dynamometer at 0 F  
and 90 F.

Special report The automobile

- 26 It's the super-driver of both technology and society Trevor O. Jones
- 30 The automobile: for better or worse Ronald K. Jurgen  
*Amid controversy about automobile design, there is unanimity on its use of electronics*
- 34 Automotive electronics I: smaller and better Trevor O. Jones  
*Electronics may be the only viable solution to the performance challenge of today's au*
- 36 Automotive electronics II: the microprocessor is in G. Puckett, J. Marley, J. Gragg  
*This IC will satisfy energy requirements—and the consumer's preference for luxury*
- 46 Balancing clean air against good mileage Charles M. Helnen, Eldred W. Beckman  
*Contradictory specifications for emissions and fuel economy require compromises*
- 51 EPA: how it fights pollution Eric O. Stork  
*Steps required include the extensive application of ICs for engine control*
- 52 Closed-loop engine control George W. Niepoth, Stephen P. Stonestreet  
*Circuits to aid emissions control may be the forerunner of onboard engine "tuning"*
- 56 Engine options for the car of tomorrow John D. Withrow, Jr.  
*Competing combustion engines, as well as electrics, are considered as contenders*
- 63 DOE: outlook on fuel economy John J. Brogan, Charles S. Chen  
*A three-pronged program that could save hundreds of thousands of barrels of oil daily*
- 64 Cars and kilowatts Harvey J. Schwartz  
*While Detroit remains uncommitted to electrics, industry overseas has taken the plunge*
- 69 The U.S. promotes electric vehicles Vincent J. Esposito  
*An Energy Department program is designed to encourage research and experimentation*
- 70 Automating the production line Edward A. Torrero  
*Henry Ford began it all when he designed the first car-assembly line in 1914*
- 73 Fast bonding cuts auto costs Eugene Mittelmann  
*An important development speeds assembly through "welding" of plastic to metal*
- 76 Unjamming traffic congestion Edward A. Torrero  
*Computer-based systems can speed traffic, increase safety, and improve gasoline mil*
- 80 Toward safer motor vehicles Ronald L. Braun  
*Many accidents can be survived, or avoided, by adopting vehicle designs that stress sa*
- 87 Safety: the view from NHTSA Joan Claybrook  
*New legislation promises to make cars safer, cheaper to repair, and less polluting*
- 88 Autos and public transit: friends or foes? Gadi Kaplan  
*A "balanced" transportation system would utilize both private cars and public transit*
- 92 The consumer and the automobile Gertrude I. McWilliams  
*Buyers don't always choose what's best, nor do makers always predict demand accur*
- 96 Looking down the road Robert L. Maxwell  
*A projection of how five major factors will impact the car of tomorrow*

# OPTIMIZATION OF AUTOMOTIVE ENGINE FUEL ECONOMY AND EMISSIONS

R. Prabhakar, S. J. Citron, and R. E. Goodson

Journal of Dynamic Systems, Measurement, and Control, Transaction of the ASME, June 1977, vol. 99, series G, no. 2, p. 109-117

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1977  
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- Intersociety Energy Conversion Engineering Conference, 12th, Washington, 1977.**  
**Proceedings of the 12th Intersociety Energy Conversion Engineering Conference, Washington, D. C., August 29 through September 2, 1977. — La Grange, Ill. :**
- 779001 — **Comparing Alternative Methods of Improving Fuel Economy**, S. Luchter, *U.S. Dept. of Transportation*, Washington, D.C., C. J. Daye, *ERDA*, Washington, D.C. .... 2
- 779002 — **The ERDA Automotive Gas Turbine Program**, C. S. Chen, *ERDA*, Washington, D.C. .. 10 )
- 779004 — **Improving Automobile Fuel Economy with Advanced Transmissions**, S. Luchter, R. Kost, *ERDA*, Washington, D.C. .... 18
- 779005 — **Continuously-Variable Transmission Concepts Suitable for Flywheel Hybrid Automobiles**, A. A. Frank, N. H. Beachley, R. W. Harter, A. P. Dietrich, K. C. Lau, *University of Wisconsin*, Madison, Wis. .... 26

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343  
.S88  
1976

## Symposium on Future Automotive Fuels—Prospects, Performance, and Perspective ...1977. (Card 2)

October 6-7, 1976] / edited by Joseph M. Colucci and Nicholas E. Gallopoulos. New York : Plenum Press, 1977].

ix, 380 p. : ill. ; 26 cm.

Includes bibliographical references and index.

Attention is given to the future demand for automotive fuels, the U.S. energy outlook through 1990, aspects of energy conservation and fuel-vehicle optimization, and opportunity for maximizing transportation energy conservation, the matching of future automotive fuels and engines for optimum energy efficiency, coal as a source of automotive fuels, motor fuels from oil shale, and the influence of nuclear energy on transportation fuels. The automotive utilization of intermediate-term future fuels is discussed, taking into account the characteristics of conventional fuels from nonpetroleum sources, the application of a new combustion analysis method in the study of alternate fuel combustion and emission characteristics, engine performance and exhaust emission characteristics of a methanol-fueled automobile, the combustion of methanol in an automotive gas turbine, and alternative fuels for automotive diesel engines. Hydrogen as a reciprocating engine fuel is considered in connection with an evaluation of long-term future fuels. The use of hydronitrogens, such as hydrazine and ammonia, as future automotive fuels is also discussed.

G.R.

card 3)

77N21639# ISSUE 12 PAGE 1618 CATEGORY 44  
76/03/00 25 PAGES UNCLASSIFIED DOCUMENT

UTTL: Use of hydrogen in automotive engines

AUTH: A/GUPTA, C. P.

CORP: Roorkee Univ. (India). AVAIL:NTIS SAP: HC A99/MF A01

In Miami Univ. First World Hydrogen Energy Conf. Proc., Vol. 3 25 p (SEE N77-21626 12-44)

MAJS: /\*AUTOMOBILE FUELS/\*ENERGY STORAGE/\*HYDROGEN FUELS/\*INTERNAL COMBUSTION ENGINES

MINS: / AUTOMOBILE ENGINES/ ENVIRONMENT POLLUTION/ FUEL CONSUMPTION/ HYDROCARBON FUELS/ HYDROGEN-BASED ENERGY

ABA: Author

ABS: The case of hydrogen as automotive engine fuel is discussed in the context of environment pollution and scarcity of hydrocarbon fuels. The development of the air-breathing, hydrogen IC engine is reviewed. The hydrogen-oxygen high temperature cycle power plant for automotive applications is also examined. Various methods of storing hydrogen on automotive vehicles are discussed and the resulting vehicle weights and ranges compared. The production, transportation, storage and distribution of hydrogen are briefly considered.



TL  
151.6  
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1976

**Motor Industry Research Association.**  
Vehicle fuel economy : effects of aerodynamics and gearing : a report / prepared by the Motor Industry Research Association ; for the Mechanical Engineering and Machine Tools Requirements Board. [London] : Department of Industry, [1976.]  
[3], 113 p. : ill., map ; 30 cm.  
£22.00

1. Motor vehicles -- Fuel

TJ  
210  
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v.2

**Stratified charge engines, v.2. /** edited by Frediano V. Bracco. -- London: Gordon and Beach, c1976.  
111 p. : ill. ; 27 cm.  
Cover title.  
A collection of papers published in Combustion science and technology, v. 12, no. 1/2/3.  
1. Automobiles--Motors. I. Bracco, Frediano V., ed. II. Combustion science and technology. v. 12, nos. 1/2/3.

TL  
210  
.P64

**Power plants and future fuels : conference** sponsored by the Combustion Engines Group and the Automobile Division of the Institution of Mechanical Engineers, London 21-22 January, 1975. -- London ; New York : Published by Mechanical Engineering Publications for the Institution of Mechanical Engineers, c1976.  
ix, 229 p. : ill. ; 31 cm. -- (Conference publication - Institution of Mechanical Engineers ; CPl- 1975)

77N21633# ISSUE 12 PAGE 1617 CATEGORY 44  
76/03/00 16 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Dynamic tests of hydrogen-powered IC engines --- for mass transit vehicles  
AUTH: A/WOOLLEY, R. L.; B/GERMANE, G. J. PAA: B/(Brigham Young Univ.)  
CORP: Billings Energy Research Corp., Provo, Utah. CSS: (Hydrogen Engine Research.) AVAIL:NTIS SAP: HC A99/MF A01  
In Miami Univ. First World Hydrogen Energy Conf. Proc., Vol. 3 16 p (SEE N77-21626 12-44)  
MAJS: /\*DYNAMIC CHARACTERISTICS/\*ENERGY POLICY/\*HYDROGEN FUELS/\*INTERNAL COMBUSTION ENGINES/\*MOTOR VEHICLES  
MINS: / FUEL CONSUMPTION/ FUEL SYSTEMS/ MATHEMATICAL MODELS/ PROPULSIVE EFFICIENCY/ TRANSPORTATION ENERGY  
ABA: Author  
ABS: A speed governed, sawtooth, torque time cycle was used in checkout and calibration of computer controlled engine test cells. This cycle makes possible comparison of integrated steady-state data with dynamic test results. Integration of available data indicates that a factor of 1.5 (50% improvement) is a valid number for estimation of hydrogen engine efficiency from a knowledge of gasoline efficiency. Vehicle driving dynamics for a transit vehicle are simulated for a simplified road cycle. An example calculation indicates that the efficiency penalty resulting from the addition of a 4,000 lb metal hydride tank is more than offset by efficiency benefits in the hydrogen engine. The energy savings with a heavier, hydrogen-powered transit vehicle was predicted to be nearly 30%.

77A45956 ISSUE 21 PAGE 3614 CATEGORY 44  
76/00/00 234 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Power plants and future fuels: Proceedings of the Conference, London, England, January 21, 22, 1975  
SAP: \$38  
Conference sponsored by the Institution of Mechanical Engineers, London and New York. Mechanical Engineering Publications, Ltd., 1976. 234 p  
ABA: R.D.V.  
ABS: The contributed papers lay emphasis on vehicular power plants. The outlook for the stratified-charge engine, automotive gas turbine engine, Stirling engines, Wankel rotary engine, the Honda CVCC carbureted three-valve stratified-charge engine, fuel cell power plants, spark-ignition engines, diesel engines for small vehicles, sodium/sulfur battery (for railroad traction), and aviation engines are discussed. Alcohol-gasoline mixtures, coal (for diesels), methanol/gasoline blends, fuel vaporization schemes, and use of heat pipes in fuel vaporization are dealt with.



77A18932# ISSUE 6 PAGE 864 CATEGORY 44  
76/00/00 12 PAGES UNCLASSIFIED DOCUMENT

UTTL: Hydrogen as a fuel in compression ignition engines  
AUTH: A/KARIM, G. A. PAA: A/(Calgary, University, Calgary, Alberta, Canada)  
Archiwum Termodynamiki i Spalania, vol. 7, no. 1, 1976, p. 89-100.  
MAJS: /\*COMPRESSIBILITY EFFECTS/\*ENGINE DESIGN/\*HYDROGEN FUELS/\*HYDROGEN OXYGEN ENGINES/\*IGNITION/\*PISTON ENGINES  
MINS: / COMPRESSED GAS/ EXTERNAL COMBUSTION ENGINES/ GAS MIXTURES/ GAS PRESSURE/ HYDROGEN-BASED ENERGY/ INTERNAL COMBUSTION ENGINES/ PERFORMANCE PREDICTION  
ABA: (Author)  
ABS: Review is made of some of the main operational features associated with the use of hydrogen as a fuel in engines. The paper presents some findings of an investigation into the performance of a compression ignition engine fueled with hydrogen. Most of the experimental work reported relates to a laboratory dual fuel engine where hydrogen was introduced just outside the engine cylinder, mixed with the necessary air, compressed and then ignited by the injection of a small quantity of liquid fuel near the end of compression. Moreover, the role of various operating parameters on the onset of autoignition in a motor engine in the absence of a deliberate source of ignition was established analytically. The paper then concludes with the examination of the prospects of using hydrogen-oxygen mixtures in engines.

77N21631# ISSUE 12 PAGE 1617 CATEGORY 44  
76/03/00 3 VOLS 23 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Water induction in hydrogen-powered IC engines  
AUTH: A/WOOLLEY, R. L.; B/HENRIKSEN, D. L.  
CORP: Billings Energy Research Corp., Provo, Utah.  
AVAIL NTIS SAP: HC A99/MF A01  
In Miami Univ. First World Hydrogen Energy Conf. Proc., Vol. 3 23 p (SEE N77-21620 12-44)

ABA: Author  
ABS: Addition of water to the hydrogen-air mixture in the intake manifold is an effective means of both suppressing the tendency to backflash and reducing the production of oxides of nitrogen. Tests are run on a Dodge 440 CID V8 engine having a compression ratio of 12 to 1. Dramatic reduction in oxides of nitrogen is observed as the water flow is increased, yet essentially no change is observed in either power or efficiency. Exhaust temperature, nitrogen oxide, and equivalence ratio is measured at each exhaust valve. It is found that a large cylinder to cylinder variation in nitrogen oxide production is caused by slight non-uniformity in mixing of the hydrogen-air streams. It is further shown that nitrogen oxide production is an exponential function of equivalence ratio, water to hydrogen mass ratio, and engine speed.

77A49153 ISSUE 23 PAGE 4020 CATEGORY 44  
76/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Thermal energy storage and transportation  
AUTH: A/SEVCIK, V. J. PAA: A/(Argonne National Laboratory, Argonne, Ill.)  
In: Sharing the sun: Solar technology in the seventies; Proceedings of the Joint Conference, Winnipeg, Canada, August 15-20, 1976. Volume 10. (A77-48910 23-44) Cape Canaveral, Fla., International Solar Energy Society, 1976, p. 177-182.  
ERDA-sponsored research.  
MAJS: /\*AUTOMOBILE ENGINES/\*HEAT STORAGE/\*TRANSPORTATION ENERGY  
MINS: / ELECTRIC AUTOMOBILES/ LITHIUM FLUORIDES/ PROPULSION SYSTEM PERFORMANCE/ STIRLING CYCLE/ STORAGE BATTERIES  
ABA: J.M.B.  
ABS: The application of thermal energy storage concepts to the design of an automobile propulsion system capable

of competing with that of electric vehicles is discussed. The proposed vehicle would utilize a thermal storage source, such as a molten salt heat battery, to power a thermal engine. Various materials, including lithium fluoride, sodium chloride, or silicon are considered as candidates for use in the heat batteries; thermal engines based on the Brayton, Rankine, or Stirling cycle are also assessed. It is concluded that a lithium-fluoride battery used in conjunction with a Stirling engine may be the best prospect for development. The reliability, safety and simplicity of the proposed vehicle are analyzed.

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no.143

Catalysts for the control of automotive pollutants: a symposium / sponsored by the Division of Industrial and Engineering Chemistry, and co-sponsored by the Board-Council Committee on Chemistry and Public Affairs ... et al. at the 167th meeting of the American Chemical Society, Los Angeles, Calif., April 2-4, 1974 ; James E. McEvoy, chairman. -- Washington : American Chemical Society, c1975.

77N12536# ISSUE 3 PAGE 356 CATEGORY 44 RPT#:  
PB-256117/3 DOT-IST-76-57-2 CNT#: DOT-OS-30112  
75/12/00 22 PAGES UNCLASSIFIED DOCUMENT

UTTL: Increased fuel economy in transportation systems by  
use of energy management: Second year's program.  
Executive summary TLSP: Final Report

AUTH: A/BEACHLEY, N. H.; B/FRANK, A. A.

CORP: Wisconsin Univ., Madison. CSS: (Engineering  
Experiment Station.) AVAIL:NTIS SAP: HC A02/MF  
A01

MAJS: /\*AUTOMOBILE ENGINES/\*FLYWHEELS/\*FUEL CONSUMPTION/\*  
MECHANICAL DRIVES

MINS: / ENERGY CONSUMPTION/ EXHAUST GASES/ TRANSPORTATION  
ENERGY

ABA: GRA

ABS: Design and analytic evaluation of experimental  
vehicles equipped with a flywheel energy management  
powerplant (FEMP) are covered. Development of modeling  
techniques that permit the accurate prediction of  
transient emissions from an automobile over any  
driving cycle are discussed. A limited investigation

of the fuel-saving potential of relatively  
straightforward changes to transmissions and  
drivetrain systems is included.

**N74-22600**

**L**

**RESEARCH ON GROUND PROPULSION SYSTEMS. (Hearings  
before the Subcommittee on Space Science and  
Applications of the Committee on Science and  
Astronautics, U.S. House of Representatives,  
93rd Congress, 2nd Session, Feb.4-6,1974).  
1974. 137p.**

**93rd Congress, 2nd Session**

**93rd Congress, 2nd Session**

**No.26**

**Committee on Science and Astronautics**

## AUTOMOTIVE POWERPLANTS - GAS TURBINES

79N26484\*# ISSUE 17 PAGE 2279 CATEGORY 44  
79/06/00 19 PAGES UNCLASSIFIED DOCUMENT

UTTL: Candidate power-conversion system cycles, appendix A

AUTH: A/STOCHL, R. J.

CORP: National Aeronautics and Space Administration, Lewis  
Research Center, Cleveland, Ohio. AVAIL NTIS SAP:  
HC A11/MF A01

In Its Handbook of Data on Selected Eng. Components  
for Solar Thermal Appl. p 191-209 (SEE N79-26476  
17-44)

MAJS: /\*BRAYTON CYCLE/\*ELECTRIC GENERATORS/\*RANKINE CYCLE/\*  
STIRLING CYCLE

MINS: / ENGINE TESTS/ GAS TURBINE ENGINES/ HIGH TEMPERATURE  
TESTS/ PERFORMANCE TESTS/ PISTON ENGINES/ SOLAR ENERGY  
CONVERSION/ SYSTEMS ENGINEERING/ THERMAL ENERGY

ABA: S.E.S.

ABS: The Rankine cycle, Brayton cycle, and Stirling cycle  
are described for solar thermal applications. The  
basic cycle configuration, its operation, and the  
basic relations for calculating cycle efficiencies and  
work outputs are presented. The system modifications  
used to increase performance over that of the basic  
cycle are discussed.

### COMPUTER STUDY AIDS AUTOMOTIVE GAS TURBINE.

D. G. Evans & T. J. Miller

Automotive Engineering, Vol. 86, No. 6, June 1978,  
p. 56-60

Computerized analysis of the aerospace gas turbine has helped  
the growth of its automotive counterpart.

PROBLEMS AND PROGRESS IN DEVELOPING THE  
AUTOMOTIVE GAS TURBINE.....ASME GAS TURBINE  
DIVISION.

Mechanical Engineering, Vol. 100, No. 5,  
May 1978, p. 40-49

***While there are no dramatic break-throughs to announce, steady progress is being made in the evolution of a commercially viable automotive gas turbine. This article—pursuing the theme originally introduced in a feature story in the March 1977 issue of ME—highlights some of the main points that were discussed by a panel of experts at the recent Vehicular Gas Turbine Forum in Philadelphia.***

NASA TM-78956

COLD-AIR PERFORMANCE OF FREE POWER TURBINE DESIGNED FOR  
112-KILOWATT AUTOMOTIVE GAS-TURBINE ENGINE.

III - EFFECT OF STATOR VANE END CLEARANCES ON PERFOR-  
MANCE.

Milton G. Korfkey and Kerry L. McLallin.

National Aeronautics and Space Administration  
Lewis Research Center

DOE/NASA/1011-78/29

December 1978

L



79A10100 ISSUE 1 PAGE 111 CATEGORY 44 CNT#:  
EC-77-C-03-1574 78/00/00 6 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: The external combustion steam injected gas turbine for  
cogeneration

AUTH: A/BOYCE, M. P.; B/VYAS, Y. K.; C/TREVILLION, W. L.  
PAA: C/(Boyce Engineering International, Inc.,  
Houston, Tex.)

In: Intersociety Energy Conversion Engineering  
Conference, 13th, San Diego, Calif., August 20-25,  
1978. Proceedings, Volume 1. (A79-10001 01-44)  
Warrendale, Pa., Society of Automotive Engineers,  
Inc., 1978, p. 860-865.

MAJS: /\*ENERGY CONVERSION EFFICIENCY/\*EXTERNAL COMBUSTION  
ENGINES/\*FLUID INJECTION/\*GAS TURBINES/\*STEAM FLOW/\*  
TURBOGENERATORS

MINS: / ENERGY TECHNOLOGY/ ENGINE DESIGN/ FEASIBILITY  
ANALYSIS/ PERFORMANCE PREDICTION/ RELIABILITY  
ENGINEERING

ABA: B.J.

ABS: A theoretical analysis is presented which shows the  
technical feasibility of an external combustion  
steam-injected gas turbine. The system can utilize any  
fuel from natural gas to solid fuels such as lignite  
or waste, without any significant deterioration in  
performance and reliability. The study included the  
concept of total utilization of energy by cogeneration  
and the utilization of low pressure steam for maximum  
power and efficiency. A cycle analysis which  
determined the most desirable pressure ratio for steam  
injection is discussed. In addition, criteria for  
selecting a gas turbine and modifications required to  
convert it to an external combustion steam-injected  
gas turbine are discussed.

78A50253 ISSUE 23 PAGE 4223 CATEGORY 44  
78/07/00 4 PAGES In GERMAN UNCLASSIFIED DOCUMENT

UTTL: Cold energy --- liquefied natural gas evaporation  
energy utilization

AUTH: A/WEBER, D. PAA: A/(Gutehoffnungshuette Sterkrade  
AG, Oberhausen, West Germany)  
Energie, vol. 30, July 1978, p. 238-241. In German.

ABA: M.L.

ABS: A procedure for obtaining low-cost electricity by  
using evaporated LNG to drive gas turbines in a closed  
process is proposed. The gas turbine in conjunction  
with a diesel motor would be located at an LNG  
terminal and is thought to be capable of providing 211

MW at an efficiency of 60%. The components and the  
circulation scheme of the proposed gas turbine are  
considered, and characteristics of existing gas  
turbines, LNG terminals, LNG evaporation, and cost  
estimates are explained.

ADVANCES IN AUTOMOTIVE GAS TURBINES.  
S.O. Kronogard.

Mechanical Engineering, v.99, no.10, Oct.1977,  
p.38-43.

*Here's an advanced three-shaft gas turbine  
designed for compact cars that is expected  
to be competitive with other automotive  
power systems. Reduced engine weight and  
improved idle and part load fuel economy  
are predicted. There is an unusually close  
design integration between the turbine and  
the transmission.*

TJ  
163.2  
.N47

New options in energy technology / sponsored  
by the American Institute of Aeronautics and  
Astronautics, Edison Electric Institute, IEEE  
Power Engineering Society. -- New York :  
American Institute of Aeronautics and Astro-  
nautics, c1977.

149 p. : ill. ; 29 cm.

Papers nos. 77-1004-771034

Includes bibliographical references.

Future of Nox Emissions Control in Utility Gas Turbine Engines - S. A.  
MOSIER and R. M. PIERCE.....

Gas Turbine HTGR - A Total Energy Utilization Option - A. J. GOODJOHN and  
S. H. LAW.....

EVALUATING CHARACTERISTIC TIME EMISSIONS  
PREDICTIONS FOR THREE VEHICULAR GAS TURBINE  
COMBUSTIONS

J. Energy, v.1, no. 4, July-August 1977,  
p. 250-256.



# AUTOMOTIVE POWERPLANTS - RANKINE AND STIRLING

TK  
2896  
.155  
1979

**Intersociety Energy Conversion Engineering Conference, 14th, Boston, 1979.**  
Proceedings of the 14th Intersociety Energy Conversion Engineering Conference, Boston, Massachusetts, August 5-10, 1979. -- Washington, D. C. : American Chemical Society, c1979.

## **Stirling Engine Analysis**

799230  
**Guidelines for Preliminary Design of Stirling Engines, G. Walker** ..... 1066 )

799231  
**The Choice of Gas Exchange Model in Stirling Cycle Machine Analysis, G.T. Reader and M. Cross** ..... 1069

799233  
**Preliminary Test Results with a Stirling Laboratory Research Engine, B.D. Nguyen, D.D. Schmit and F.W. Hoehn** ..... 1075

799235  
**The Effects of Higher Harmonics on the Preliminary Design of Rhombic Drive Stirling Engines, C. Hooper and G.T. Reader** ..... 1082

799236  
**A Review of Stirling Cycle Machine Analysis, I. Urieli** ..... 1086

799237  
**An Isothermal Second Order Stirling Engine Calculation Method, W.R. Martini and B.A. Ross** ..... 1091

799238

**Modes of Operation of a Jet-Stream Fluidyne-Stirling, G.T. Reader and P.D. Lewis** 1098

799239  
**A Prototype Liquid-Piston Free-Displacer Stirling Engine, L.F. Goldberg and C.J. Rallis** 1103

799240  
**Comparison of Measurements with Calculation of a 5-Watt Free-Displacer, Free-Power Piston Hydraulic Output Stirling Engine, A. Bennett and W.R. Martini** ..... 1109

799241  
**Closed-Form Solutions for a Coupled Ideal Analysis of Free-Piston Stirling Engines, D.M. Berchowitz and G. Wyatt-Mair** ..... 1114

79N32636\*# ISSUE 23 PAGE 3103 CATEGORY 44  
RPT#: NASA-CR-162304 JPL-PUB-79-86 CNT#: NA-7-100  
79/09/15 77 PAGES UNCLASSIFIED DOCUMENT

UTTL: Stirling laboratory research engine survey report  
AUTH: A/ANDERSON, J. W.; B/HOEHN, F. W.  
CORP: Jet Propulsion Lab., California Inst. of Tech., Pasadena. AVAIL NTIS SAP: HC A05/NF A01  
MAJS: /\*AIR BREATHING ENGINES/\*PISTON ENGINES/\*SURVEYS  
MINS: / EVALUATION/ MANUFACTURING/ TABLES (DATA)/ UTILIZATION

ABA: G.Y.  
ABS: As one step in expanding the knowledge relative to and accelerating the development of Stirling engines, NASA, through the Jet Propulsion Laboratory (JPL), is sponsoring a program which will lead to a versatile Stirling Laboratory Research Engine (SLRE). An objective of this program is to lay the groundwork for a commercial version of this engine. It is important to consider, at an early stage in the engine's development, the needs of the potential users, so that the SLRE can support the requirements of educators and researchers in academic, industrial, and government laboratories. For this reason, a survey was performed, the results of which are described.

TK  
2896 Intersociety Energy Conversion Engineering  
.155 Conference, 14th, Boston, 1979.  
1979 Proceedings of the 14th Intersociety  
Energy Conversion Engineering Conference,  
Boston, Massachusetts, August 5-10, 1979.  
-- Washington, D. C. : American Chemical  
Society, c1979.

## Stirling Engine Applications

799242  
DOE Stationary External Combustion Engine  
Program: Status Report, J. Facey, W. Bunker,  
R.E. Holtz and K.L. Uherka ..... 1120

799243  
Stirling Engine Combustion and Heat Trans-  
port System Design Alternatives for Station-  
ary Power Generation, K.L. Uherka, J.G.  
Daley, R.E. Holtz and W.P. Teagan ..... 1124

799244  
A Solar-Stirling Small Power System, R.L.  
Pons ..... 1131

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A Small Free-Piston Stirling Refrigerator,  
A.K. de Jonge ..... 1136

799246  
Free-Piston Stirling Engine Technology  
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Miniaturized Stirling Engine for Artificial  
Heart Power, R.P. Johnston and J.E. Alexan-  
der ..... 1152

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Operating Characteristics of a Small Stirling  
Engine, G. Walker, G.L. Ward and J. Slowley ..... 1156

799250  
A Stirling Engine Powered Total Energy Sys-  
tem: Recreational Vehicle Application, L.  
Johansson and W.B. Lampert ..... 1162

799251

Predicted Performance and Testing of a Pre-  
Prototype, Small, Stirling Engine/Generator,  
D. Lehrfeld, A. Sereny, R.L. Wiley and J. Bled-  
soe ..... 1169

799252  
Advances in Stirling Engine Technology, J.R.  
Senft ..... 1175

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Performance of a Free-Piston Stirling Engine  
for a Heat Pump Application, W.S. Chiu and  
W.B. Carlson ..... 1181

799254  
State of a Stirling Engine Powered Heat Acti-  
vated Heat Pump Development, J.A.M. van  
Eekelen ..... 1186

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Design Characteristics of an Advanced Stir-  
ling Engine Concept, J. Vos ..... 1191

799258  
A Variable Angle Wobble Plate Drive for a  
Stroke Controlled Stirling Engine, R.J. Meijer  
and B. Ziph ..... 1197

79N26476\*# ISSUE 17 PAGE 2278 CATEGORY 44  
RPT#: NASA-TM-79027 E-9822 DOE/NASA/1060-78/1 CNT#:  
EX-76-A-29-1060 79/06/00 240 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Handbook of data on selected engine components for  
solar thermal applications

CORP: National Aeronautics and Space Administration, Lewis  
Research Center, Cleveland, Ohio. AVAIL NTIS SAF  
HC A11/MF A01

Prepared for DOE

MAJS: /\*DATA BASES/\*ENGINE PARTS/\*SOLAR ENERGY CONVERSION/\*  
THERMAL ENERGY

MINS: / AC GENERATORS/ BRAYTON CYCLE/ CLOSED CYCLES/  
HANDBOOKS/ PISTON ENGINES/ RANKINE CYCLE/ SOLAR  
GENERATORS/ SPEED CONTROL/ STIRLING CYCLE/ TECHNOLOGY  
UTILIZATION/ WORKING FLUIDS

ANN: A data base on developed and commercially available  
power conversion system components for Rankine and  
Brayton cycle engines, which have potential  
application to solar thermal power-generating systems  
is presented. The status of the Stirling engine is

discussed.

ABA: S.E.S.

79A51883 ISSUE 23 PAGE 4381 CATEGORY 44  
79/00/00 7 PAGES UNCLASSIFIED DOCUMENT

UTTL: Stirling engine combustion and heat transport system design alternatives for stationary power generation  
AUTH: A/UHERKA, K. L.; B/DALEY, J. G.; C/HOLIZ, R. E.; D/TEAGAN, W. P. PAA: C/(Argonne National Laboratory, Argonne, Ill.); D/(Arthur D. Little, Inc., Cambridge, Mass.)  
In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1, (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 1124-1130.  
MAJS: /-COAL UTILIZATION/-EXTERNAL COMBUSTION ENGINES/-HEAT TRANSFER/-POWER PLANTS/-STIRLING CYCLE/-THERMODYNAMIC EFFICIENCY  
MINS: / COMBUSTION CONTROL/ COMBUSTION PRODUCTS/ ELECTRIC GENERATORS/ ENGINE DESIGN/ HEAT EXCHANGERS/ TABLES (DATA)

ABA: B. J.

ABS: The paper reviews a study in support of the DOE Fossil Fuel Utilization Division program for development of large (500 to 300 Hp) Stirling engines for stationary power generation. Emphasis is on coal-based systems with high conversion efficiency for application in the industrial, commercial and residential sectors to provide electrical and thermal capacity at the point of use. Methods for integrating various coal combustors with Stirling engines are examined. Consideration is given to such indirect systems for transporting thermal energy as heat pipes, two-phase liquid metal reflux boilers, and single-phase liquid or gaseous forced circulation loops; heat transfer characteristics are presented.

79N26481\*# ISSUE 17 PAGE 2278 CATEGORY 44  
79/06/00 15 PAGES UNCLASSIFIED DOCUMENT

UTTL: Speed reducers-increasers  
AUTH: A/MROZ, T. S.  
CORP: National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. AVAIL.NTIS SAP: HC A11/MF A01  
In its Handbook of Data on Selected Eng. Components for Solar Thermal Appl. p 159-173 (SEE N79-26476 17-44)

ABA: S.E.S.

ABS: Prime movers such as steam-organic engines, gas turbines, Stirling engines, and piston engines were designed for peak efficiency at specific operating parameters. Gear systems are used to reduce or increase the output speed of the prime mover to the speed requirement of the driven machine, at the operational load. The configurations of gear systems discussed include: (1) Horizontal parallel-shaft offset; (2) Horizontal parallel-shaft in-line; (3) Horizontal right angle; (4) Vertical right angle; and (5) Epicyclic.

79A51885 ISSUE 23 PAGE 4381 CATEGORY 44  
79/00/00 10 PAGES UNCLASSIFIED DOCUMENT

UTTL: Current free-piston Stirling engine technology and applications  
AUTH: A/GOLDWATER, B. S. PAA: A/(Mechanical Technology, Inc., Latham, N.Y.)  
In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1, (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 1142-1151.  
MAJS: /-ELECTRIC POWER PLANTS/-ENGINE DESIGN/-PISTON ENGINES /-PRODUCT DEVELOPMENT/-STIRLING CYCLE  
MINS: / CONFIGURATION MANAGEMENT/ ELECTRIC GENERATORS/ GRAPHS (CHARTS)/ OPTIMIZATION/ TABLES (DATA)/ TECHNOLOGY UTILIZATION  
ABA: (Author)  
ABS: The present level of the technology in free-piston Stirling engines (FPSE) has been achieved over the past few years on two fronts. Analytically, the design and optimization tools have been continuously upgraded and compared with experimental data from a number of engine configurations. Optimization computer codes

have been developed to allow rapid convergence on unconstrained engine design variables consistent with application requirements. In this manner, the complex tradeoffs that exist between engine efficiency, cost, and life can be established with a reasonable manpower effort and computer operating time. Experimentally, both engine performance and potential reliability have been demonstrated; although significant work remains to achieve the goals of the identified applications for this engine technology. This paper will discuss technology levels and potential applications being worked on by MIT.

79N26480\*# ISSUE 17 PAGE 2278 CATEGORY 44  
79/06/00 31 PAGES UNCLASSIFIED DOCUMENT

UTTL: Stirling engine characteristics  
AUTH: A/CAMERON, H. M.  
CORP: National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. AVAIL.NTIS SAP: HC A11/MF A01  
In its Handbook of Data on Selected Eng. Components for Solar Thermal Appl. p 127-157 (SEE N79-26476 17-44)

ABA: S.E.S.

ABS: The Stirling engine is described for the following factors: (1) excellent fuel economy; (2) low exhaust emissions; (3) multifuel capability; (4) flat torque curve; and (5) low noise level. The Stirling cycle, free piston engines, and the seals and hydrogen containment are discussed.



TJ Greater Los Angeles Area Energy Symposium, Los Angeles, 1978.

.G74 Greater Los Angeles Area Energy Symposium  
1978

- Performance Comparison of Some Rankine/Brayton Cycle Combinations for Solar-Electric Conversion — Dr. Felix L. Lansing, Jet Propulsion Laboratory
- Presses, I. Los Angeles and Scientists.

Various configurations combining solar-Rankine and fuel-Brayton cycles were analyzed in order to find the arrangement which has the highest thermal efficiency and the smallest fuel share. A numerical example is given to evaluate both the thermodynamic performance and the economic feasibility of each configuration. The solar-assisted regenerative Rankine cycle was found to be leading the candidates from both points of energy utilization and fuel conservation.

78N31533\*# ISSUE 22 PAGE 2959 CATEGORY 44  
RPT#: NASA-TM-78919 E-9656 DOE/NASA/1040-78/1 CNT#:  
EC-77-A-31-1040 78/07/00 42 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Initial test results with a single-cylinder rhombic-drive Stirling engine --- to be applied to automobile engine design to conserve energy TLSP: Final Report

AUTH: A/CAIRELLI, J. E.; B/THIEME, L. G.; C/WALTER, R. J.  
CORP: National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. AVAIL.NTIS SAP: HC A03/MF A01

MAJS: /\*AUTOMOBILE ENGINES/\*ENERGY CONSERVATION/\*ENGINE DESIGN/\*ENGINE TESTS/\*STIRLING CYCLE

MINS: / ENERGY TECHNOLOGY/ FUEL CONSUMPTION/ HELIUM/ HYDROGEN/ PERFORMANCE TESTS

ABA: J.M.S.

ABS: A 6 kW (8 hp), single-cylinder, rhombic-drive Stirling engine was restored to operating condition, and preliminary characterization tests run with hydrogen and helium as the working gases. Initial tests show the engine brake specific fuel consumption (BSFC) with hydrogen working gas to be within the range of BSFC observed by the Army at Fort Belvoir, Virginia, in 1966. The minimum system specific fuel consumption (SFC) observed during the initial tests with hydrogen was 669 g/kW hr (1.1 lb/hpx hr), compared with 620 g/kWx hr (1.02 lb/hpx hr) for the Army tests. However, the engine output power for a given mean compression-space pressure was lower than for the Army tests. The observed output power at a working-space pressure of 5 MPa (725 psig) was 3.27 kW (4.39 hp) for the initial tests and 3.80 kW (5.09 hp) for the Army tests. As expected, the engine power with helium was substantially lower than with hydrogen.

79N12547\*# ISSUE 3 PAGE 346 CATEGORY 44 RPT#:  
NASA-TM-75442 CNT#: NASW-3199 78/11/00 14 PAGES  
UNCLASSIFIED DOCUMENT

Original language document was announced as A75-23509

UTTL: The Stirling engine for vehicle propulsion

AUTH: A/KUHLMAN, P.

CORP: National Aeronautics and Space Administration, Washington, D. C. AVAIL.NTIS SAP: HC A02/MF A01  
Transl. by Kanner (Leo) Associates, Redwood City, Calif. Transl. into ENGLISH from VDI-Berichte (West Germany), no. 224, 1974 p 87-91

MAJS: /\*AUTOMOBILE ENGINES/\*STIRLING CYCLE

MINS: / ECONOMIC FACTORS/ EXHAUST GASES/ PERFORMANCE TESTS/ RESEARCH AND DEVELOPMENT

ABA: Author

ABS: The performance data of experimental Stirling engines are considered along with questions of exhaust-gas composition, engine noise, engine volume and weight, engine control, and the engine-starting process. The Stirling engine can use practically any liquid or gaseous fuel for its operation. It is found that technically a use of the Stirling engine in motor vehicles is feasible. Economic questions related to an introduction of the Stirling engine are discussed along with possible new developments which could improve the economic situation in favor of a use of Stirling engine.

BON15567# ISSUE 6 PAGE 759 CATEGORY 44 RPT#:  
COO-2764-T3 CNT#: EY-76-C-02-2764 78/12/15 52  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Free-piston Stirling engine demonstration test plan  
CORP: Mechanical Technology, Inc., Latham, N. Y.

AVAIL.NTIS SAP: HC A04/MF A01

MAJS: /\*ENGINE TESTING LABORATORIES/\*INTERNAL COMBUSTION ENGINES/\*PISTON ENGINES/\*STIRLING CYCLE

MINS: / AC GENERATORS/ ENGINE TESTS/ PROPULSION SYSTEM PERFORMANCE

ABA: DOE

ABS: The plan for testing the demonstrator of a free-piston Stirling engine power system is presented. The test hardware is a free-piston Stirling engine prime mover driving a linear alternator. The demonstrator system is basically a modular assembly. The modules are the reciprocating alternator section, engine section, heater head insulation package assembly, and the pressure vessel. The test objective is to demonstrate a system with greater than 30 percent overall efficiency at 1 kW, 45 Hz operating conditions, and to identify and isolate engine losses to provide a basis for future engine improvements.



79A10205 ISSUE 1 PAGE 118 CATEGORY 44 78/00/00  
4 PAGES UNCLASSIFIED DOCUMENT

UTTL: A free-piston Stirling engine for small solar power plants

AUTH: A/PRAST, G.; B/DE JONGE, A. K. PAA: B/(Philips' Gloeilampenfabrieken, Philips Research Laboratories, Eindhoven, Netherlands)  
In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings, Volume 3. (A79-10001 01-44) Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 1826-1829.

MAJS: /\*ELECTRIC POWER PLANTS/\*PISTON ENGINES/\*SOLAR GENERATORS/\*STIRLING CYCLE

MINS: / ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY

ABA: (Author)

ABS: After a discussion of the requirements needed in a heat engine for a small solar thermal power plant a description is given of a free-piston Stirling engine, which might fulfil these requirements. The theory for the movements of the piston and displacer in the free-piston engine are given, and with a qualitative description it is shown how the machine has to be designed to reach the frequency wanted and that complete automatic operation between zero and full load is possible. Some preliminary results of a laboratory model are given.

78N74466\* CATEGORY 44 RPT#:  
NASA-NEWS-RELEASE-78-48 P78-10046 78/03/27 4 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: NASA, DOE award contract for stirling engine development

CORP: National Aeronautics and Space Administration, Washington, D. C. SAP: Avail: NASA Scientific and Technical Information Facility, P.O. Box 8757, B.W.I. Airport, Md. 21240

MAJS: /\*AUTOMOBILE ENGINES/\*CONTRACTS/\*ENGINE DESIGN/\*STIRLING CYCLE

MINS: / ENERGY POLICY/ EXHAUST GASES/ FUEL CONSUMPTION

PRINT 11/2/850-967 TERMINAL=33  
80N70182\*# CATEGORY 44 RPT#: NASA-CR-159435  
COO-4396-2 CNT#: EC-77-C-02-4396 78/00/00 97  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Automotive Stirling engine development program TLEF: Quarterly Technical Progress Report, Jan. 1978 - Mar. 1978

AUTH: A/KITZNER, E. W.

CORP: Ford Motor Co., Dearborn, Mich. AVAIL:NTIS  
Prepared for NASA and DOE

MAJS: /\*AUTOMOBILE ENGINES/\*AUTOMOBILE FUELS/\*COMBUSTION EFFICIENCY/\*FUEL CONSUMPTION/\*STIRLING CYCLE

MINS: / DYNAMOMETERS/ ENERGY CONVERSION/ GASOLINE/ POLLUTION CONTROL

77A12665 ISSUE 2 PAGE 231 CATEGORY 44 76/00/00  
8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Fuel economy potential of a combined engine cooling and waste heat driven automotive air-conditioning system

AUTH: A/BALASUBRAMANIAM, M.; B/LOWI, A.; C/SCHRENK, G. L.; D/DENTON, J. C. PAA: A/(TRW, Inc., Energy Systems Planning Div., McLean, Va.); B/(Terraqua, Inc., San Pedro, Calif.); C/(Pennsylvania, University, Philadelphia, Pa.); D/(American Technological University, Killeen, Tex.)  
In: Intersociety Energy Conversion Engineering Conference, 11th, State Line, Nev., September 12-17, 1976, Proceedings, Volume 1. (A77-12602 02-44) New York, American Institute of Chemical Engineers, 1976, p. 25-32.

MAJS: /\*AIR CONDITIONING/\*AUTOMOBILE ENGINES/\*COOLING SYSTEMS/\*ENGINE COOLANTS/\*FUEL CONSUMPTION/\*WASTE ENERGY UTILIZATION

MINS: / ENERGY TECHNOLOGY/ RANKINE CYCLE/ VAPOR JET

ABA: (Author)

ABS: An organic fluid engine cooling system combined with a novel jet-vapor-compression automotive air-conditioning system is considered as an alternative to conventional belt driven vapor compression systems added on to the water cooled power plant. The energy significance of accessory dead weight and engine drag is evaluated and the value of

shifting from a prime shaft driven system to a waste heat recovery system is derived. Based on a single model year fleet equipped with the hypothetical heat recovery system it is shown that the annual energy cost of automotive air-conditioning usage could be reduced by more than 70%. The salient features of this novel Rankine bottoming cycle approach and some of its eccentricities are also described.

78A36868 ISSUE 15 PAGE 2761 CATEGORY 44  
77/00/00 3 PAGES UNCLASSIFIED DOCUMENT

UTTL: Some results of an experimental investigation of a Stirling engine --- in solar energy systems

AUTH: A/UMAROV, G. IA.; B/TRUKHOV, V. S.; C/KLIUCHEVSKII, IU. E.; D/TURSUNDAEV, I. A.; E/ORDA, E. P.; F/VOGULKIN, N. P. PAA: F/(Akademiya Nauk Uzbekskoi SSR, Fiziko-Tekhnicheskii Institut, Tashkent, Uzbek SSR)

(Gellotekhnika, no. 4, 1977, p. 34-37.) Applied Solar Energy, vol. 13, no. 4, 1977, p. 26-28, Translation.

MAJS: /\*ENGINE DESIGN/\*PISTON ENGINES/\*SOLAR ENERGY CONVERSION/\*STIRLING CYCLE/\*THERMODYNAMIC EFFICIENCY

MINS: / ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY

ABA: Ion. JI

ABS: (For abstract see Issue 02, p. 251, Accession no. A78-12391)

77N81332# CATEGORY 44 RPT#: C00-2631-15 PR-15  
CNT#: EY-76-C-02-2631 76/00/00 12 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: A 80-100HP stirling engine feasibility study TLSP:  
Progress report, Jul. - Sep. 1976

AUTH: A/POSTMA, N. D.

CORP: Ford Motor Co., Dearborn, Mich. AVAIL NTIS

MAJS: /AUTOMOBILE ENGINES/ DESIGN ANALYSIS/ PERFORMANCE  
TESTS

MINS: / COST ANALYSIS/ ECONOMICS/ FUEL CONSUMPTION

## AUTOMOTIVE POWERPLANTS - ELECTRIC AND HYBRID

### THE PROMISE AND PUZZLE OF ELECTRIC VEHICLES.

Electric Power Research Institute Journal, vol 4,  
no 9, November 1979, p. 6-15.

Dormant for half a century, the electric vehicle (EV) is being revived. The prospect of slashing oil dependence and urban pollution in tandem is enough to inspire hope and stimulate large-scale research into such technical problems as batteries. But even here success will not be enough. Mass production and widespread use of EVs will require thoughtful development of every element in the transportation infrastructure-

### ELECTRIC CARS ADVANCE IN THE US. Clive Cookson.

New Scientist. v. 83, no. 1164, July 19, 1979, p. 198-200.

Electric vehicles now cost about the same to run as petrol-driven ones but have inferior performance. They also save oil but not energy. With its urgent need to reduce oil consumption the US is working hard to overcome the basic weakness of present day electric vehicles.

TL220.H35

Automobiles - Electric

## **ELECTRIC AUTOMOBILES**

Energy, Environmental, and  
Economic Prospects for the Future

by William Hamilton

General Research Corporation,  
Santa Barbara, California

Will electric cars have sufficient speed and range for general use? Will they cost less than conventional cars? Will they save petroleum—even with the need to burn oil to generate electricity for recharging? Will they reduce air pollution?

These are just a few of the many questions answered by this timely book covering all important aspects of electric automobiles. Answering the need for an objective analysis of the advantages and disadvantages of electric cars, the book presents quantitative estimates of the benefits and costs to be expected from the large-scale use of such vehicles in the United States. Its purpose is to discuss a spectrum of possibilities and to support balanced decisions without advocating a particular policy about the future use of electric cars.

TK Intersociety Energy Conversion Engineering  
2896 Conference, 14th, Boston, 1979.  
.155 Proceedings of the 14th Intersociety  
1979 Energy Conversion Engineering Conference,  
Boston, Massachusetts, August 5-10, 1979.  
-- Washington, D. C. : American Chemical  
Society, c1979.

## Batteries for Electric Vehicles

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N80-12553/ Air Force Academy, Colo. Research Lab.  
THE USAF ACADEMY FLYWHEEL-ELECTRIC CAR PRELIMINARY DESIGN REPORT Progress Report, 1 Oct. 1977 - 31 May 1979  
David D. Ratcliff May 1979 47 p refs  
(AF Proj 2303)  
(AD-A071242; FJSRL-TR-79-0006) Avail: NTIS  
HC A03/MF AQ1 CSCL 13/6

Although problems caused by pollution and declining petroleum reserves have caused renewed interest in electric vehicles, currently-available lead-acid batteries impose performance limitations which are unacceptable to most drivers. These limitations, specifically low range and acceleration, are greatly improved by the addition of a flywheel and continuously-variable transmission to the power train of the electric vehicle. This paper describes a low-technology flywheel-electric car built by U.S. Air Force Academy cadets and faculty members in the Department of Physics under funding provided by Frank J. Seiler Research Laboratory. The car design discussed appears to offer the possibility for a four-passenger urban vehicle with a range of 70-100 miles and acceleration performance comparable to that of current sub-compact cars. This performance is achieved with a simple driving system which is comparable to that in current automatic transmission cars. The paper also details the benefits and problems resulting from the low-technology design chosen and provides trade-off analyses on some of the specific problems inherent in the use of a flywheel in the power train of a vehicle. Finally, the paper suggests future improvements which could lower the weight of the vehicle, make the transmission shifting more precise, and improve the performance of the car on grades. GRA

N80-10684/ California Univ., Livermore. Lawrence Livermore Lab.  
EFFECT OF MECHANICAL ENERGY STORAGE SYSTEMS ON THE CHARACTERISTICS OF ELECTRIC VEHICLES  
Martin W. Schwartz 14 May 1979 7 p Presented at the 14th Intersoc. Energy Conversion Conf., Boston, 5-10 Aug. 1979. Sponsored by the Am. Chem. Soc.  
(Contract W-7405-eng-48)  
(UCRL 82710; Conf-790803-17) Avail: NTIS  
HC A02/MF A01

Batteries for electric vehicle propulsion were investigated to see if effective trade-offs between short term peak power capability and energy storage capacity are possible. It was found that batteries in combination with a mechanical energy storage device can optimize both power and range capability of an electric vehicle. Equations were derived for determining the vehicle mass fraction of the mechanical energy storage system that is required to achieve a vehicle mass saving or increase in range. The extent to which mechanical energy storage systems can improve electric vehicle performance was found to depend upon the battery type and the vehicle power/mass requirements. DOE



- TK  
2896 Intersociety Energy Conversion Engineering  
.155 Conference, 14th, Boston, 1979.  
1979 Proceedings of the 14th Intersociety  
Energy Conversion Engineering Conference,  
Boston, Massachusetts, August 5-10, 1979.  
-- Washington, D. C. : American Chemical  
Society, c1979.

## Electric Vehicle Systems

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CN-150,647 (1979)  
THE LITHIUM-WATER-AIR BATTERY FOR AUTOMOTIVE  
PROPULSION. A. Donald Galbraith. (1979).  
19p.

(Lockheed Missiles and Space Co.,  
Palo Alto, Calif.)

Automobiles, Electric  
Batteries  
Lithium-water

- TL  
220 Electric and hybrid vehicles / edited by  
.E36 M. J. Collie. -- Park Ridge, N. J. : Noyes  
Data Corp., 1979.  
xiii, 633 p. : ill. ; 25 cm. -- (Energy  
technology review ; no. 44)  
Includes bibliographical references.  
ISBN 0-815507-54-2  
I. Electric vehicles. I. Collie, M. J.  
II. Series.

An Averaging Battery Model for a Lead-Acid Battery  
Operating in an Electric Car  
by J.M. Bozek

Dept. of Energy Report DOE/NASA/1014-79/5  
also NASA TM-79321  
December 1979

A battery model is developed based on time averaging the current or power, and is shown to be an effective means of predicting the performance of a lead-acid battery. The effectiveness of this battery model was tested on battery discharge profiles expected during the operation of an electric vehicle following the various SAE J227a driving schedules. The averaging model predicts the performance of a battery that is periodically charged (regenerated) if the regeneration energy is assumed to be converted to retrievable electrochemical energy on a one-to-one basis.

N80-14973# California Univ., Livermore. Lawrence Livermore Lab.

**ASSESSMENT OF THE APPLICABILITY OF MECHANICAL ENERGY STORAGE DEVICES TO ELECTRIC AND HYBRID VEHICLES. VOLUME 1: EXECUTIVE SUMMARY**  
M.S. Thesis

M. W. Schwartz 1 May 1979 17 p refs  
(Contract W-7405-eng-49)  
(UCRL 52773-Vol-1) Avail: NTIS HC A02/MF A01

The power and energy required in a storage device to realize specific improvements upon current and near-term electric vehicle performance specifications are calculated. A review of candidate mechanical energy storage devices concludes that only flywheels and, for some applications, hydraulic accumulators are practical in this context. With respect to each performance specification, data is presented on the vehicle-mass fraction of the mechanical energy storage system as a function of its specific energy and the overall vehicle mass. Mechanical energy storage devices may or may not improve range, depending on the particular configuration of the vehicle and the driving cycle.

DOE

N80-14972# Department of Energy, Washington, D. C.  
**COMMERCIALIZATION STRATEGY REPORT FOR ELECTRIC AND HYBRID VEHICLES**

P. Brown, P. Davis, G. Hagey, and M. Katz [1979] 91 p  
(TID-28858-Draft) Avail: NTIS HC A05/MF A01

Barriers to the commercialization of electric powered vehicle technology are identified, along with possible actions to remove specific barriers. Technical, economic, environmental, and institutional readiness are assessed. Recommended commercialization strategies and goals are presented.

K. L.

A79-31364 240 VDC electric vehicle system. K. R. Jones (Globe-Union, Inc., Milwaukee, Wis.). *Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 26-Mar. 2, 1979, Paper 790159*, 7 p.

A description is presented of work conducted by a U.S. company in connection with the objective to develop a 240 VDC electric vehicle battery power system. In principle, the considered 240 VDC system has a number of advantages with respect to the current 120 VDC series parallel configuration. It was, however, found that these advantages can only be realized by developing system components which are compatible with the new battery configuration. First experiments in which the 240 VDC battery configuration was used led to a deterioration in performance with respect to the 120 VDC system because of the incompatibility between the motor and chopper control at the higher voltage battery application.

G.R.

A79-31366 Thermal management of the lithium/metal sulfide electric vehicle. M. M. Farahat, J. A. E. Graae, A. A. Chilenskas, and D. L. Barney (Argonne National Laboratory, Argonne, Ill.). *Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 26-Mar. 2, 1979, Paper 790161*, 7 p.

Thermal management studies of the lithium-aluminum/metal sulfide battery have indicated the need for a light-weight high thermal efficiency case for electric batteries. Calculations based upon the rectangular configured MK IA battery using vacuum-foil insulation, show that the heat loss rate goal of 400 W can be met. Experimental studies directed at the determination of the reversible heating gave results that compared within 8% with theoretically derived values. Calculations based upon the 50-kWh MK II battery and a 10,000 miles driven/year show that by utilizing the thermal storage capacity of the system, essentially no additional energy is needed to keep the battery hot.

(Author)

A79-31359 ENEL experience and demonstration programs in the field of electric vehicles. A. Bossi, P. Menga, L. Paris, and M. Sforzini (Ente Nazionale per l'Energia Elettrica, Rome, Italy). *Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 26-Mar. 2, 1979, Paper 790113*, 10 p.

More than 50 battery-powered electric vehicles have been tested by ENEL, the Italian Electricity Board. A battery-powered electric van with a range of 55 km and a top speed of 60 km/h and a payload of 350 kg plus two passengers has been developed; an electric van with increased payload capacity, range and speed is currently in the design phase. An electric taxi with a range of 70 km and a top speed of 60 km/h also figures in the ENEL development program. A computerized data acquisition system for monitoring electric vehicle performance is also discussed.

J.M.B.

**A79-31351** Fiat Research Center hybrid vehicle prototype. L. Morello, R. Piccolo, and L. Ippolito (Fiat S.p.A., Turin, Italy). *Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 26-Mar. 2, 1979, Paper 790014*. 11 p. 7 refs.

Mathematical models to evaluate the energy consumption of hybrid propulsion systems are presented, and road tests of a prototype hybrid propulsion vehicle are reported. The mathematical model incorporates several component analyses, including a thermal engine represented by a fuel consumption map, an efficiency map for a compound dc electric machine, a simulation of normal battery operation, a transmission system model, and clutch and torque converter models. A modular computerized version of the mathematical models provides a flexible instrument for analyzing a number of hybrid propulsion systems. Analysis of a prototype hybrid propulsion vehicle indicates fuel savings of about 18% with respect to conventional traction vehicles. J.M.B.

**N80-14631#** Argonne National Lab., Ill.  
**ADVANCED BATTERIES FOR ELECTRIC VEHICLES: A LOOK AT THE FUTURE**

William J. Walsh. 23 Apr. 1979. 23 p. refs. Presented at the APS Meeting, Washington, D.C., 23 Apr. 1979 (Contract W-31-109-eng-38) (CONF 790484-1) Avail. NTIS HC A02/MF A01

Battery systems which are potential candidates for electric motor vehicles are discussed. These include lead acid, nickel-iron, nickel-zinc, zinc-chlorine, lithium-metal sulfide and sodium-sulfur (ceramic electrolyte). The characteristics of these batteries are discussed. Each individual battery system is found to have less than 50% probability of successful development and commercialization; however, the cumulative probability that at least one of the batteries would be successfully developed is judged to be greater than 75%. It is predicted that the magnitude of the market penetration of electric motor vehicles will depend on the severity of future liquid-fuel shortages along with the cost and quality of the advanced batteries. DOE

**A79-31353** Mechanical hybrid vehicle simulation. F. G. Willis, W. F. Kaufman, and G. A. Kern (Ford Scientific Research Laboratories, Dearborn, Mich.). *Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 26-Mar. 2, 1979, Paper 790015*. 13 p.

A method for optimizing the engine/secondary usage strategy of a hybrid vehicle is given. A powertrain simulation is combined with dynamic programming techniques for calibration optimization and a sequential algorithm for specifying optimal operating points for both engine and secondary systems. An overview of road-load matching and strategy requirements is presented. A.A.

**A79-51819** Current development activities on electric vehicles in Europe. L. Ojefors (Swedish National Development Co., Akersberg, Sweden). In: *Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1*. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 596-601. 28 refs.

European electric vehicle development activities are surveyed. The efforts of England, France, Federal Republic of Germany, Italy, Belgium, Holland, Switzerland, and Sweden are reviewed. Attention is given especially to efforts in England where the Greater London Council electric vehicle trial includes the testing of the Crompton K2 and the Bedford Lucas electric vehicles. In addition, VW and Bosch, Daimler Benz, Varta test vehicles in the Federal Republic of Germany are discussed. Also covered are French efforts to develop light trucks, vans, and vehicles, as well as Italy's evaluation studies and electric city cars and vans. M.E.P.

**A79-51820** The effect of mechanical energy storage systems on the characteristics of electric vehicles. M. W. Schwartz (California, University, Livermore, Calif.). In: *Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1*. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 617-621.

Batteries for electric vehicle propulsion can be developed to effect trade-offs between short-term peak power capability and energy storage capacity. Such batteries in combination with a mechanical energy storage device can optimize both power and range capability of an electric vehicle. Equations are derived for determining the vehicle mass fraction of the mechanical energy storage system that is required to achieve a vehicle mass saving or increase in range. The extent to which mechanical energy storage systems can improve electric vehicle performance depends upon the battery type and the vehicle power/mass requirements. (Author)

**A79-51823** Wheel Hub motors applied to electric vehicle propulsion. A. W. Beishline and G. S. Goldman (Gold Line Engineering, Power Wheel Div., Fullerton, Calif.). In: *Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1*. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 632-636.

Electric vehicle systems, from subways to ski-lifts, are a prevalent form of transportation throughout the world; and electric automobiles are again drawing serious attention because they are a convenient and economical means of converting energy into motive power for people and material. New and exciting concepts of people movers include electrically powered cable-suspension railways that can be constructed with minimal disruption of existing facilities. This mode of transportation is seriously needed to solve the urgent problem of urban mass transit. (Author)



**A80-15658**      **Electric and hybrid vehicles.** Edited by M. J. Collie. Park Ridge, N.J., Noyes Data Corp. (Energy Technology Review, No. 44), 1979. 652 p. \$36.

The report presents data developed by the ERDA with the assistance of NASA on the state of the art of electric and hybrid vehicles. Attention is given to three sources of data: (1) controlled tests of a representative sample of commercially available and experimental electric and hybrid vehicles, (2) information and data from the literature and vehicle manufacturers, and (3) the experience of users, both fleet operators and individual owners. Topics covered include electric vehicles - theoretical background, vehicle components such as tires, traction motors, controllers, batteries, and battery chargers, as well as hybrid vehicles, and electrochemical devices. Discussion of foreign technology covers foreign all-electric and hybrid-electric vehicle R&D, power sources, drive systems, and control systems for electric vehicles, military electric vehicles, computer analysis of foreign traction batteries in all-electric vehicles. Finally, the latest developments available Jan. 1979 are reviewed including R&D and updated assessment.      M.E.P.

**A79-51827**      **A comparison of metal-air batteries for electric vehicle propulsion.** W. A. Bryant and E. S. Buzzelli (Westinghouse Research and Development Center, Pittsburgh, Pa.). In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings. Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 651-653. 15 refs. Research supported by the U.S. Department of Energy.

A comparison is made among four metal-air systems being considered for future use in commuter electric vehicles. The anode materials are lithium, aluminum, zinc and iron. The lithium-air system is still in an early stage of development. A proposed mechanically rechargeable aluminum-air system is potentially capable of superior performance but its relative cost of ownership and operation is expected to be high. Several slurry zinc-air systems are being developed which avoid the traditional problems associated with the plate-type zinc electrode. A fully-developed iron-air system, especially one equipped with a bifunctional air electrode, is expected to be low-weight and economical.      (Author)

**A79-49380**      **Outlook for electric road vehicles.** W. Hamilton (General Research Corp., Santa Barbara, Calif.). In: Utilization of alternative fuels for transportation; Proceedings of the Symposium, Santa Clara, Calif., June 19-23, 1978. (A79-49376 22-28) New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 97-106.

Electric vehicles in very large numbers could be recharged from coal or nuclear facilities now available or projected at U.S. utilities. Resultant savings of petroleum could be correspondingly large. With future batteries, the driving range of electric cars will become adequate for most automotive travel. Unless gasoline prices increase drastically in relation to oil prices or government intervenes directly, however, relatively few electric cars are likely to be sold in this century, because they generally will cost more and do less than conventional cars.      (Author)

**A79-51824**      **An electric vehicle drive concept using a centrifugal clutch.** J. P. Altendorf (Volkswagenwerk AG, Wolfsburg, West Germany). In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings. Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 637-642. 10 refs.

The drive concept described in this paper uses a separately excited dc motor controlled only by a transistor field control, a centrifugal clutch and a transmission with the choice of three gear ratios, thus offering automatic driving behaviour in addition to high efficiency. The operation of this drive system is described in details. Performance data - hill climbing ability, maximum speed, acceleration - are derived from the motor and clutch characteristics for a vehicle equipped with this drive concept. These figures are compared with actual test values taken from a test vehicle, that has been built. Diagrams of the dynamic driving behaviour are shown and discussed. They are also compared with those of other drive concepts.      (Author)

**A79-31365**      **Development status and experience of Varta's battery systems gained on electric vehicles tested in West Germany under actual operating conditions.** U. W. Peters (Varta Batteries, Ltd., Canada). *Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 26-Mar. 2, 1979, Paper 790160.* 10 p. 6 refs.

Report sums up performance data obtained on lead-acid batteries and accessories especially designed for electric road vehicles. Also encompasses special technologies such as central electrolyte refilling system, forced cooling and central venting. Further describes Varta's latest accomplishments for reduced maintenance and improvement in reliability. Another objective is exploitation of improved technologies for motive power batteries for applications such as fork lift trucks. Furthermore, it presents development stage of Varta's improved nickel-iron FENOX-battery.      (Author)

**A79-49488**      **Battery systems for electric vehicles - A state-of-the-art review.** D. A. J. Rand (Commonwealth Scientific and Industrial Research Organization, Institute of Earth Resources, Melbourne, Australia). *Journal of Power Sources*, vol. 4, Aug. 1979, p. 101-143. 176 refs.

The future economy demands the development of more efficient power sources for urban vehicles. These sources could be electrochemical systems, i.e., batteries or fuel cells or battery-fuel cell hybrids. The purpose of this paper is to review the current world effort being directed towards developing advanced battery systems for electric vehicle power source applications. The relative merits of the various battery types under examination will be discussed in terms of their efficiency, performance, convenience, cost, and the availability of their component active materials. These factors are important in deciding whether a particular system will be suitable for use in electric vehicles.      (Author)



**A79-31363** Electric vehicle battery development. C. W. Fleischmann (Eltra Corp., Electric Vehicle Group, Plymouth Meeting, Pa.). *Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 26-Mar. 2, 1979, Paper 790158*. 11 p. 32 refs. ERDA Contracts No. 31-109-38-3628; No. 31-109-38-4206.

A description is presented of the development of a new lead-acid battery for electric vehicle propulsion applications. The battery which is being developed uses expanded metal, nonantimonial alloy grids, enveloped separation/retention, and high-rate production methods of packaging including through-the-wall construction. The battery is expected to meet the Department of Energy goals for the improved state-of-the-art electric vehicle battery and to be further improved to meet the Department of Energy goals for the advanced battery. G.R.

**A79-51782** Prediction of vehicle performance and its sensitivity to component improvements - Application to electric and H<sub>2</sub>-fueled vehicles. R. F. McAlevy, III (Stevens Institute of Technology, Hoboken, N.J.). In: *Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1*. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 337-342. 8 refs.

Simple, algebraic equations were used to relate vehicle mass, WT, and energy consumption, C, to parameters describing vehicle components characteristics. By differentiation, the sensitivity of WT and C to component improvements was determined and used to formulate a rational R & D investment policy. For H<sub>2</sub>-fueled vehicles and electric vehicles, EV's, R & D investment in improving vehicle energy-storage device was predicted to produce greater decreases in WT and C than investment in the power-train. Using a published forecast of component characteristics, WT and C for both kinds of vehicles were projected into future time-frames. Numerical results are presented. (Author)

**A79-31357** EPRI/TVA pilot electric vehicle demonstration program. R. J. Ferraro (Electric Power Research Institute, Palo Alto, Calif.) and D. L. Harbaugh (Southern California Edison Co., Los Angeles, Calif.). *Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 26-Mar. 2, 1979, Paper 790110*. 9 p.

The considered program is mainly concerned with the identification of the potential interactions between large-scale use of electric vehicles (EVs) and utility operations. By combining reliable EVs with present day state-of-the-art data collection technology the two year pilot demonstration will establish the characteristics and capabilities of EVs in a representative operating environment within the electric utility industry. The key requirements for an EV support infrastructure are to be established for viable, larger-scale demonstration programs. Other objectives are related to the identification of optimum ways for the electric utility industry to participate in larger-scale demonstration programs, and the identification of high priority areas of research, design, and development for EVs. G.R.

## Energy Conversion, v.18, 1978, p.127-134. MODELING ENERGY AND POWER REQUIREMENTS OF ELECTRIC VEHICLES

PETER D. BLAIR

School of Public and Urban Policy, University of Pennsylvania,  
Philadelphia, PA, U.S.A.

(Received 1 March 1978)

**Abstract** - In this paper we present a model of electric vehicle performance that can be used to estimate energy and power requirements of vehicles in various driving environments. The model is developed from basic vehicle parameters and, when coupled with a simple model of battery performance, is used to examine effective ranges and per-mile traveled energy requirements of electric vehicles as compared with internal combustion powered vehicles under similar driving conditions.

A number of classes of vehicles are discussed, each of which is identified by characteristic values of the model's vehicle and driving pattern parameters. A simplified driving cycle is adopted and range calculations are made on each of the vehicle classes using a simple model of battery performance for a typical lead-acid battery and for a theoretical high-performance battery.

The relationships developed here not only provide a simple estimating model of vehicle performance, but also lay the groundwork for a more comprehensive simulation model, the development of which is currently in progress. The simplified model has a number of restrictions on modeling alternative driving patterns. These restrictions are discussed along with logical extensions to the model that address the restrictions.

The preliminary results of the model indicate that electric vehicles, employing either current technology or high-performance batteries, may be energy efficient in urban environments. However, in inter-city applications, where internal combustion engines are most efficient, the comparative energy efficiency of electrics is minimal.

TJ  
153 Energy Technology Conference, 5th, Washington,  
D.C., 1978.

.E4787 Energy technology V : challenges to  
1978 technology : proceedings of the fifth  
Energy Technology Conference, February 27-  
March 1, 1978, Washington, D.C. / edited by  
Richard F. Hill. -- Washington : Government  
Institutes, 1978.

xiii, 1063 p. : ill.

1. Power (Mechanics)—Congresses.

ELECTRIC VEHICLES CHALLENGE BATTERY TECHNOLOGY p. 387  
John L. Hartman, Elton J. Cairns, Earl H. Hietbrink, Electrochemistry Department,  
General Motors Research Laboratories

20-51000

## Automobiles, Electric

NASA CP-7

FOURTH NASA INTER-CENTER CONTROL SYSTEMS CONFERENCE.  
(Held Boston, Mass., Nov. 4-5, 1969). 1978. 505p.

Conference on Control Systems

1978

Nov. 4-5,  
1969

Minimum Energy Control of a Class of Electrically  
Driven Vehicles Page 387

Yilmaz E. Sahinkaya

JPL, California Institute of Technology

Formerly X72-74701

NASA TM X-68317

N79-32130\*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena  
THREE STATE-OF-THE-ART INDIVIDUAL ELECTRIC AND  
HYBRID VEHICLE TEST REPORTS, VOLUME 2  
Nov. 1978 329 p refs  
(Contract EC-77-A-31-1011)  
(NASA-CR-162311: HCP/M1011-03/2-Vol-2) Avail. NTIS  
HC A15/MF A01

Procedures used in determining the energy efficiency and  
economy of a gasoline-electric hybrid taxi, an electric passenger  
car, and an electric van are described. Tabular and graphic data  
show results of driving cycle and constant speed tests, energy  
distribution to various components, efficiency of the components,  
and, for the hybrid vehicle, the emissions. A R H

THE HYBRID ELECTRIC VEHICLE DEVELOPMENT AND FUTURE  
PROSPECTS, by James R. Bumby.

Futures, vol. 10, no. 5, October 1978, p. 438-442.

Over the last decade or so significant  
efforts have been made to develop not  
only vehicles powered by heat engines  
or electricity but also hybrid vehicles.

A hybrid vehicle can be defined as a  
vehicle which is powered by two or  
more energy sources providing vehicle  
propulsion simultaneously for part or all  
of the time.<sup>1</sup> This report is concerned  
only with hybrid vehicles in which one

or more of the energy sources is electric  
(usually a battery). The additional  
energy source is generally one or more  
of the following; an internal combustion  
(ic) engine, a flywheel, a pneumatic  
accumulator or a secondary battery.

Why develop hybrid electric  
vehicles? The answer lies in the relative  
advantages and disadvantages of ic-  
engined and electric vehicles.

N80-11954\*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena  
A SURVEY OF ELECTRIC AND HYBRID VEHICLE SIMULA-  
TION PROGRAMS Final Report  
J. Bevan, D. A. Heimburger, and M. A. Metcalfe Nov. 1978  
110 p refs  
(Contract EC-77-A-31-1011)  
(NASA-CR-162457: HCP/M1011-04) Avail. NTIS  
HC A06/MF A01 CSCL 13F

Results of a survey conducted within the United States to  
determine the extent of development and capabilities of  
automotive performance simulation programs suitable for electric  
and hybrid vehicle studies are summarized. Altogether,  
111 programs were identified as being in a usable state. The  
complexity of the existing programs spans a range from a page  
of simple desktop calculator instructions to 300,000 lines of a  
high-level programming language. The capability to simulate  
electric vehicles was most common, heat engines second, and  
hybrid vehicles least common. Batch-operated programs are  
slightly more common than interactive ones, and one third can  
be operated in either mode. The most commonly used language  
was FORTRAN, the language typically used by engineers. The  
higher-level simulation languages (e.g. SIMSCRIPT, GPSS,  
SIMULA) used by 'model builders' were conspicuously lacking.

DOE

387

VINTAGE YEAR FOR EVs, by Clare E. Wise.

Machine Design, vol. 50, no. 28, December 1978,  
p. 40-45.

It is no longer the sign of an eccentric to be an electric-vehicle fan. General Motors  
has entered the field, along with several other corporate giants.

GETTING SERIOUS ABOUT EV MOTORS

Peter Walker

Machine Design, vol 50, no. 10, May 11, 1978, p. 108-  
112

Much has been learned about optimizing motors and batteries for maximum  
speed, range, and payload.

## ELECTRIC AUTOMOBILES? -- YES!

by Ernst Stuhlinger

Journal of Energy, vol. 2, no. 5, September 1978, p.  
279-288

Growing shortage of petroleum threatens the lifeline of conventional automobiles and makes the search for alternate transportation systems mandatory. Among several possible substitutes, the electric automobile appears promising as a short-distance commuter car (COMCAR). Its lack of pollution would be an additional advantage. A systematic user test and demonstration project was undertaken to analyze the performance capability of a commercially available electric automobile. The project included a six-month driving program by volunteer test drivers who used the car for daily trips to and from work. Although the performance of the test vehicle was only about half as good as can be expected with an electric commuter car specifically designed for its purpose, the reaction of volunteer test drivers in the COMCAR project was positive. Experience and data obtained in this project led to recommendations for further steps toward the development and introduction of large numbers of electric commuter cars for urban transportation.

TK        Electric motor handbook / editor, E. H.  
2511        Werninck. -- London ; New York : McGraw-  
.E42        Hill, c1978.  
          xvi, 629 p. : ill. ; 26 cm.  
          Includes bibliographical references  
          and index.  
          ISBN 0-07-084488-7  
          1. Electric motors--Handbooks, manuals,  
          etc. I. Werninck, E. H.

## BATTERY AND FUEL CELL TECHNOLOGY SURVEYED.

Thomas J. Lund & Joseph F. McCartney

Automotive Engineering, Vol. 86, No. 7,  
July 1978, p. 68-72.

*The future of the electric vehicle depends on advancement of battery technology. This article discusses leading-edge battery developments and fuel cells for special-purpose vehicle power.*

34128 (COO-4250-02) Factors affecting the commercialization of electric and hybrid vehicles. (Purdue Univ., Lafayette, IN (USA). Inst. for Interdisciplinary Engineering Studies). Oct 1978. Contract EC-77-S-02-4250. 185p. Dep. NTIS, PC A09/MF A01.

Factors affecting commercialization of electric and hybrid vehicles (ehvs) were investigated, and the economic and financial aspects of the commercialization process were evaluated. Societal institutions which can both help and hinder acceleration of commercialization were studied. The role of the DOE ehv demonstration program in promoting this commercialization was examined. It was concluded that: the ehv market demand established by the demonstration program would be a major stimulus to present and potential producers; federal planning grants and loan guarantees will provide financial incentive to small business producers; the market segment most appropriate for EV use is in the commercial, urban, light-load delivery fleet; existing technology, passenger EVs are not economically competitive with internal combustion engine vehicles (ICVs), and will not be until advanced battery technology lowers battery costs and EVs are produced in sufficient quantity that production costs--and, therefore, market prices--are competitive with those of new, subcompact automobiles; and existing financial, insurance, and legal institutions will support the sale and use of ehvs, but performance must be improved if EHV's gain unrestricted license to use public roadways in the U.S.

CAR FOR TOMORROW: A QUASI-ELECTRIC-DRIVE VEHICLE.  
Energy and Technology Review, June 1977, p.10-16.

An electric vehicle with an internal-combustion-engine adjunct could be the alternative automobile to compete successfully with today's car and to help reduce petroleum use.

A PUSH FROM CONGRESS AND EVs WILL ROLL.  
C.E. Wise.  
Machine Design, July 21, 1977, p.27-30.

Passage of Public Law 94-413 commits ERDA to the purchase of 7,500 electric vehicles by the early 80's and the Postal Service to adding 750 1/4-ton EVs to its fleet of 350 electric jeeps.



## Automobiles, Electric

### The Consumer's ELECTRIC CAR

Ernest H. Wakefield

Dr. Wakefield explains why he considers the electric car the logical next step in automotive evolution, and why it is the natural replacement for today's conventional cars (fatally dependent on dwindling supplies of fossil fuel). Anything that would prove helpful in knowing about electric cars—their design, advantages, drawbacks, operation, and future—is included.

The author took special care to make certain this unique guide to electric cars is understandable and informative to all readers including those without an engineering or scientific background. Technical data with explanatory curves and tables are included, but will not detract from the book's interest and usefulness for nonspecialists as well as experts.

Automobile enthusiasts will find this first authoritative book on electric cars beneficial. Appreciative readers will include engineers, scientists, environmentalists, automobile owners, dealers, manufacturers, those concerned about mankind's energy future, and anyone intrigued by new technology.

Dr. Wakefield does not say exactly when the electric car will become a major form of transport, but he is convinced it could be and may be soon. His purpose in writing the book has been to inform specialists and nonspecialists in advance concerning an important subject on which he has devoted many years and made himself one of the world's leading authorities. When the electric car becomes a widespread practical reality, Dr. Wakefield's contributions will be part of it. His book provides the reader with a comprehensive preview and introduction to the electric car—whose general availability he declares is clearly a question of "when," not "if."

TL 220.W35

Section One explains the design configurations of electric vehicles and then offers broad, thought-provoking information on a range of pertinent subjects from government regulations to the convincing economics of electric cars. The author's comparisons of efficiency characteristics between electric and gasoline-driven cars will startle many readers.

The basic principles of electricity are covered in Section Two clearly and simply, as preparation for Section Three which examines in precise detail the operation and technology of an electric car, the reliability of its battery and charging systems, as well as a discussion of alternate motors and controls. Section Four concludes with a vigorous consideration of the electric car's future prospects, the author's expert view on ways of achieving significantly greater mileage, and the significance of electric cars in terms of mankind's energy position.

(over)

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163.2  
.P4P

Perspectives on the energy crisis : technical, regulatory, environmental, economic, prospective. / advisory editors, Howard Gordon, Roy Meador. — Ann Arbor, Mich. : Ann Arbor Science Publishers, c1977.

2 v. : ill. ; 29 cm.

Includes bibliographies and index.

ISBN 0-25041-61-4.

STRATEGY FOR SAVING GASOLINE BY SUBSTITUTING  
LOW PERFORMANCE ELECTRIC VEHICLES . . . . . 331

(By Sumner Meyers, Institute of Public Administration, From Transportation Research Board, Special Report 169, National Academy of Sciences, 1975)

Innovative ideas concerning wider use of electric-vehicles (EVs) are offered. Methods of overcoming current technological problems in EV construction are suggested. Substantial gasoline savings are predicted through the use of EVs. An EPA estimate is that one million automobiles (17%) in Los Angeles could be changed to electrically powered vehicles without altering driver habits extensively. These arguments are part of a constantly growing effort to find reasonable alternatives to gasoline. Recognizing the economic difficulties, the author advocates special financing methods to encourage EV manufacture and use.

77A36410# ISSUE 16 PAGE 2730 CATEGORY 44  
77/06/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Electrochemical energy conversion. I - Electric vehicle propulsion

AUTH: A/HIRSCHFELD, F.

MAJS: Mechanical Engineering, vol. 99, June 1977, p. 30-35.  
/\*AUTOMOBILE ENGINES/\*COST ESTIMATES/\*ELECTRIC MOTOR VEHICLES/\*ELECTROMECHANICAL DEVICES/\*ENERGY CONVERSION EFFICIENCY/\*PROPULSION SYSTEM PERFORMANCE

MINS: / COST REDUCTION/ ENERGY TECHNOLOGY/ IRON COMPOUNDS/ LITHIUM COMPOUNDS/ NICKEL ZINC BATTERIES/ SERVICE LIFE / SULFIDES/ TECHNOLOGY ASSESSMENT

ABA: C.K.D.

ABS: Progress in the development of electrochemical cells for eventual application in automotive propulsion systems is surveyed. Test data presented for two lithium/iron sulfide cells show high specific energies; however, cost and durability problems remain to be solved. Progress has been made in reducing the cost of nickel-zinc systems. Projected cost of a 300 A-hr cell approaches \$50.00/kWh. Recent work has demonstrated stable high performance of prismatic, uncharged Li-Al/FeS cells for periods exceeding 1000 hr and 50 cycles.



- TK  
2896  
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1977  
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- Intersociety Energy Conversion Engineering Conference, 12th, Washington, 1977.**  
**Proceedings of the 12th Intersociety Energy Conversion Engineering Conference, Washington, D. C., August 28 through September 2, 1977. — La Grange, Ill. :**
- 779043 — **The Zinc-Bromine Battery: Possible Candidate for Load Leveling and Electric Vehicles, F. G. Will, General Electric Co., Schenectady, N. Y. ....** 250
- 779044 — **The Design and Development of a 30 KWH Lithium-Aluminum/Iron Sulfide Electric Vehicle Battery, W. E. Miller, V. M. Kolba, A. A. Chilenskas, Argonne National Lab., Argonne, Ill.; K. Gentry, Eagle Picher Industries ....** 256
- 779045 — **Design of a Current Technology Electric Vehicle, R. H. Guess, W. R. Nial, General Electric Co., Schenectady, N.Y.; M. A. Pocobello, Triad Services, Inc. ....** 262
- 779046 — **Flywheel Module for Electric Vehicle Regenerative Braking, G. Chang, E. L. Lustenader, E. Richter, J. S. Hickey, F. Turnbull, General Electric Co. ....** 269
- TK  
2901  
.K67
- Kordesch, Karl, 1922-**  
**Batteries / edited by Karl V. Kordesch.**  
**— New York : Marcel Dekker, c1977.**  
**2 v. : ill. *La has V. 2***  
**CONTENTS: v. 1. Manganese dioxide.—v. 2.**  
**Lead-acid batteries and electric vehicles.**  
**Includes bibliographies.**  
**ISBN 0-8247-6084-0 (v.1)**  
**ISBN 0-8247-6489-7 (v.2)**  
**1. Electric batteries. 2. Manganese dioxide. I. Title.**  
**621.35**

78N27599# ISSUE 18 PAGE 2418 CATEGORY 44 RPT#:  
 PB-278121/9 DOT-ISC-OST-77-23-4-VOL-4 77/11/00 4  
 VOLS 212 PAGES UNCLASSIFIED DOCUMENT

UTTL: Hybrid vehicle technology constraints and application assessment study. Volume 4: Sections 10, 11, and appendix TLSP: Final Report. Apr. 1975 - Jun. 1976

AUTH: A/LAPEDES, D. E.; B/HINTON, M. G.; C/FORREST, L.; D/KOHLBERGER, J.; E/RYAN, T.; F/SAMPSON, H.; G/SMALLEY, W.; H/SPEISMAN, C.; I/WHITE, H.

CORP: Aerospace Corp., El Segundo, Calif. CSS: (Environment and Energy Conservation Div.)

AVAIL NTIS SAP: HC 410/MF A01

MAJS: /\*AUTOMOBILE ENGINES/\*ENERGY CONSERVATION/\*ENGINE DESIGN/\*FUEL CONSUMPTION

MINS: / BRAKING/ EXHAUST GASES/ FLYWHEELS/ MECHANICAL DRIVES/ REGENERATION (ENGINEERING)/ STORAGE BATTERIES/ TRANSMISSIONS (MACHINE ELEMENTS)/ VEHICLE WHEELS

ABA: GRA

ABS: The hybrid vehicle's energy consumption and exhaust emissions are considered. Factors such as vehicle weight, peak cruise speed, and regenerative braking are discussed. Technological constraints to introduction of the hybrid vehicle and applications that could benefit most from its energy conservation potential are identified.

**IEEE Transactions on Vehicular Technology, v.VT-26, no.2**

May  
1977

**ELECTRIC VEHICLES AND AUTOMOTIVE ELECTRONICS.  
 (Special Issue.)**

- The Computer Simulation of Automotive Use Patterns for Defining Battery Require .....
- Comparison of Electrical Drives for Road Vehicles .....
- Advanced Motor Developments for Electric Vehicles ..... E. P. Cornell, I
- Development of a Hybrid Flywheel/Battery Drive System for Electric Vehicle Appli ..... E. L. Lustenader, R. H. Guess,
- Prime Sensors for Electronic Automotive-Engine Control .....
- System Considerations for the Design of Radar Braking Sensors .....

78N27596# ISSUE 18 PAGE 2417 CATEGORY 44 EPT#:  
PB-278118/5 DOT-TSC-OST-77-23-1-VOL-1 77/11/00 4  
VOLS 117 PAGES UNCLASSIFIED DOCUMENT

UTTL: Hybrid vehicle technology constraints and application  
assessment study. Volume 1: Summary TLSP: Final  
Report, Apr. 1975 - Jun. 1976

AUTH: A/LAPEDES, D. E.; B/HINTON, M. G.; C/FORREST, L.;  
D/KOHLBERGER, J.; E/RYAN, I.; F/SAMPSON, H.;  
G/SMALLEY, W.; H/SPEISMAN, C.; I/WHITE, H.

CORP: Aerospace Corp., El Segundo, Calif. CSS: (  
Environment and Energy Conservation Div.)  
AVAIL:NTIS SAP: HC A06/MF A01

MAJS: /\*AUTOMOBILE ENGINES/\*ENERGY CONSERVATION/\*ENGINE  
DESIGN/\*FUEL CONSUMPTION

MINS: / BRAKING/ EXHAUST GASES/ FLYWHEELS/ MECHANICAL DRIVES  
/ REGENERATION (ENGINEERING)/ STORAGE BATTERIES/  
TRANSMISSIONS (MACHINE ELEMENTS)/ VEHICLE WHEELS

ABA: GRA

ABS: Analyses and assessments of both heat engine/battery  
and heat engine/flywheel-powered hybrid vehicles are  
presented to determine if they could contribute to  
near-term (1980-1990) reductions in transportation  
energy consumption. The impact of hybrid vehicle use  
on vehicle-related exhaust emissions is determined,  
and the ability to accommodate a different energy  
resource base in the longer term is evaluated.  
Alternative paths for power transmission from the heat  
engine to the vehicle drive wheels are considered  
along with the potential of regenerative braking to  
reduce vehicle energy consumption.

IS AN ELECTRIC VEHICLE IN YOUR FUTURE  
Edwin C. Hackleman, Jr.  
Environmental Science & Technology  
Vol. 11: no. 9 September 1977  
p. 858-862.

Perhaps. Short-trip household and  
industrial markets are ready to be  
tapped and, once penetrated,  
a solution to our energy and  
environmental problems may be at hand

- QD Electrochemical Society.  
552 Extended abstracts. v. 77-1. Spring  
.E42 meeting, Philadelphia, Pennsylvania, May 8-  
1977 13, 1977. -- Princeton, N.J. : Electro-  
v.77-1 chemical Society, c1977.  
1027 p. : ill. ; 22 cm.  
Includes extended abstracts of Battery,  
MATERIALS AND PROCESSES FOR  
CONVENTIONAL AND ELECTRIC VEHICLES
- Modeling of Electric Vehicle Battery Applications  
L. H. Gaines and H. B. Sykes..... 805
- Current Status of the OGE Circulating Zinc-Air Vehicle  
Battery  
A. J. Appleby, J. Jaquelin, and J. P. Pompon..... 809
- New Lithium Solid Electrolytes  
H. Y-P. Hong..... 811
- Ionic Conductivity of Pure and Doped  $\text{Li}_4\text{SiO}_4$  and  
 $\text{Li}_5\text{AlO}_4$   
I. D. Raistrick, Y-W. Hu, C. Ho, and R. A. Huggins.... 813
- Lithium Ion Conductivity in Lithium Nitride  
B. A. Boukamp and R. A. Huggins..... 815
- Alkaline Cell Leakage  
M. N. Hull and H. I. James..... 818
- Studies on Corrosion of Lead Acid Battery Grids with  
Addition of Cobalt and Silver Compounds  
R. K. Galgali, P. V. Vasudeva Rao, and  
H. V. K. Udupa..... 820

- TK Anderson, Edwin P., 1895-  
2511 Electric motors / by Edwin P. Anderson.  
.A5 -- 3d ed. / rev. by Rex Miller. -- Indian  
1977c anolis : T. Audel, c1977.  
510 p. : ill. ; 22 cm.  
Includes index.  
ISBN 0-672-23264-2  
1. Electric motors. I. Miller, Rex,  
1929-

# HARWOOD'S CONTROL OF ELECTRIC MOTORS

Fourth Edition • Edited by  
**RALPH A. MILLERMASTER**

Vice President, Engineering and Development, Cutler-Hammer, Inc.

The publication of this new edition will reaffirm *Harwood's* position as a classic in its field. It features the latest hardware and techniques used in the industry and has been rewritten to keep pace with the performance requirements of today's larger, more complex machines as well as the solutions provided by the control design engineer to meet those requirements.

This Fourth Edition includes new material dealing with Static Logic, Alternating Current to Direct Current Power Conversion, and Alternating Current to Alternating Current Power Conversion. Emphasis has been placed upon gate controlled power semi-conductors used for adjustable voltage d-c drives and adjustable frequency a-c drives.

## CONTENTS:

Introduction. Electrical Diagrams. Construction of Control Apparatus. Pilot Devices and Accessories. Direct-Current Contactors and Relays. Automatic Accelerating Methods for Direct-Current Motors. The Direct-Current Shunt Motor. Shunt Field Relays and Rheostats. Direct-Current Adjustable Speed Drives. Automatic Regulating Systems. The Direct-Current Series Motor. Two Motor and Multiple Motor Drives. Dynamic Lowering Hoist Controllers. Alternating-Current Contactors and Relays. Static Logic. The Polyphase Squirrel-Cage Motor. The Wound-Rotor Motor. Alternating-Current Adjustable Speed Drives. The Synchronous Motor. Magnetically Operated Brakes. Resistor Design. Appendix: Tables of Motor Currents. References: Books on Motor Control. Index.

**A78-16943 #** Alternates to the chopper for electric vehicle speed control. R. D. Von Seggern (Cushman OMC Lincoln Engineering, Lincoln, Neb.). *Electric Vehicle Council, International Electric Vehicle Exposition and Conference, 1st, Chicago, Ill., Apr. 26-29, 1977, Paper 7742*. 11 p.

Several techniques for electric vehicle speed control are described, and their advantages and disadvantages are considered. The procedures involve the motor, field control, transmissions, multimotor drive, step resistor, or battery tapping. It is suggested that a combination of battery tapping and field weakening would permit direct motor-to-drive axle installation for many types of on-road electric vehicles and could sustain a 35 mph speed. A new technique prevents battery unbalance (difference in amounts of current drawn from the different batteries in the system), which has rendered battery tapping impractical. The main disadvantage of the chopper speed control system is its cost.  
M.L.

**N78-27547#** Gould, Inc., Rolling Meadows, Ill. Gould Labs  
**STATE-OF-THE-ART LEAD-ACID VEHICLE**  
26 Aug. 1977 64 p  
(Contract W-31-109 eng-38)  
(ANL K-77-3639-1) Avail. NTIS HC A04/MF A01

A report is given of the state of the art of electric vehicle batteries, what the technology is capable of mass producing within two years, and what are the research and development tasks that must be undertaken to achieve goals for both the improved state of the art battery and the advanced battery. Energy intensive and life intensive candidate design for electric vehicle lead-acid batteries are discussed and performance projections are tabulated.  
ERA

**A78-16923 \* #** New batteries and their impact on electric vehicles. H. J. Schwartz (NASA, Lewis Research Center, Cleveland, Ohio). *Electric Vehicle Council, International Electric Vehicle Exposition and Conference, 1st, Chicago, Ill., Apr. 26-29, 1977, Paper*. 15 p. 18 refs.

The paper is concerned with the development of electric vehicles and electric vehicle batteries. The present and predicted performance levels of some battery systems such as lead-acid, nickel-iron, nickel-zinc, and zinc-chlorine are considered, as are the characteristics that an electric vehicle must possess in order to appeal to customers. The implications of battery improvements for manufacturers of electric vehicles are discussed. Lack of knowledge of passenger range requirements for electric vehicles is noted.  
M.L.

**55182** Electric vehicle development. Stevenage, England; Peter Peregrinus Ltd. (1977) 110p. (CONF-7705136-). r.  
From Electric vehicle development, London, UK (31 May 1977).

Seventeen papers were presented at the meeting. A separate abstract was prepared for each paper. (RCK)



# ELECTROCHEMICAL ENERGY CONVERSION

Part 1—Electric Vehicle Propulsion ..... Fritz Hirschfeld

There are some promising new approaches in the works for utilizing electrochemical power sources to drive electric motorized vehicles.

Mech. Eng., v.99, no.6, June 1977, p.30-

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603  
.P6  
1976

Power Sources Symposium, 27th, Atlantic City, N.J., 1976.

[Proceedings] / sponsored by Power Sources Technical Area, Electronics Technology and Devices Laboratory, U.S. Army Electronics Command, Fort Monmouth, N.J. — Red Bank, N.J. : PSC Publications Committee, [1977]

Lithium-Chlorine Rechargeable Battery p.1

J. C. Schaefer, J. S. Thompson, T. M. Noveske, and R. E. Baker, ESB Incorporated

FeS Electrode Development for a Secondary Li-Si-FeS Battery p.3

John C. Hall, Atomics International Division, Rockwell International Corporation

Design and Performance of Lithium Aluminum/Iron Sulfide Cells p.8

R. O. Ivins, E. C. Gay, W. J. Walsh and A. A. Chilenskas, Chemical Engineering, Argonne National Laboratory

The Sodium-Sulfur Battery p.13

Steven A. Weiner, Engineering and Research Staff, Ford Motor Company

Nickel Battery Systems for Electric Vehicles p.16

L. E. Miller and R. A. Brown, Electronics Division, Couples Department, Eagle Industries, Inc.

The Requirements for Batteries for Electric Vehicles

Harvey J. Schwartz, Lewis Research Center p.20

Federal Battery Program for Transportation Uses

A. R. Landgrebe, K. Klunder, U.S. Energy Research and Development Administration

N. P. Yao, Argonne National Laboratory p.23

77A12708 ISSUE 2 PAGE 235 CATEGORY 44 CNT#:

NSF C-805 NSF AER-73-07199 76/00/00 8 PAGES

UNCLASSIFIED DOCUMENT

UTTL: Energy saving potential of engine-electric vehicular drives

AUTH: A/UNNEWHR, L. E.; B/BAILEY, R. L.; C/STADLER, H. L.; D/TURNER, A. H. PAA: D/(Ford Motor Co., Dearborn, Mich.)

In: Intersociety Energy Conversion Engineering Conference, 11th, State Line, Nev., September 12-17, 1976, Proceedings, Volume 1. (A77-12662 02-44) New York, American Institute of Chemical Engineers, 1976, p. 430-437.

MAJS: /\*AUTOMOBILE ENGINES/\*ELECTRIC AUTOMOBILES/\*ENERGY CONSERVATION/\*FUEL CONSUMPTION/\*INTERNAL COMBUSTION ENGINES/\*POWER EFFICIENCY

MINS: / COMPUTERIZED SIMULATION/ ELECTRIC MOTOR VEHICLES/ ENERGY STORAGE

ABA: (Author)

ABS: The hybrid powertrain - combining a conventional internal combustion engine with an energy storage system - has the potential for a significant reduction of fuel consumption in vehicles during metro driving. The overall energy savings possible through the use of hybrid powertrains in a variety of vehicle types is calculated and analyzed. Comparisons are made with all-electric and conventional powertrains and the parallel on/off hybrid is found to be superior in fuel economy during metro/highway driving to both of these powertrains.

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1976

Intersociety Conference on Transportation, 4th, Los Angeles, 1976.

Proceedings / Fourth Annual Intersociety Conference on Transportation, July 19-23, 1976, Los Angeles, California. — New York : American Society of Mechanical Engineers, c1976.

648 p. in various pagings : ill. ; 28 cm. Includes bibliographical references.

A Development of High Efficiency Electric Mini-Cars

Paul R. Shipps

I. American

ESF-3



N71-25572 Automobiles, Electric L

TECHNICAL INFORMATION FOR CONGRESS. (Report to the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives, 92nd Congress, 1st Session, prepared by the Science Policy Research Division, Congressional Research Service, Library of Congress, Apr. 25, 1969, Revised Apr. 15, 1971). 1971. 845p. (Committee Print).

92nd Congress, 1st Session

92nd Congress, 1st Session Serial A

Committee on Science and Astronautics

Chapter Four—The Economic Impact of Electric Vehicles. A Scenario by Bruce C. Netschert.

Utility industry	749
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Low use factor	750
Varying demand	751
Pollution prospect	752
Oil industry	753
Other industries	754
Service station	755
Railroads	756
Government revenues	757
Price advantage?	759

TK

2851

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1970

Harwood, Paisely Beach, 1894-

Harwood's control of electric motors.

[Edited by] Ralph A. Millermaster. 4th ed. New York, Wiley Interscience [1970] xi, 498 p. illus. 23 cm.

Half-title: Control of electric motors.

1. Electric controllers. 2. Electric motors. I. Millermaster, Ralph A., 1905- ed. II. Title. III. Title: Control of electric motors.

TK

2511

.L55

Lloyd, Thomas Cox.

Electric motors and their applications [by] Tom C. Lloyd. New York, Wiley-Interscience [1969]

ix, 332 p. illus. 23 cm.

1. Electric motors. I. Title.

ORIGINAL PAGE IS  
OF POOR QUALITY

AUTOMOTIVE POWERPLANTS - DIESEL AND STEAM

TELEMETRY AIDS ROTARY ENGINE STUDY  
Philip M. Leucht and Donald J. Mandley  
Automotive Engineering  
Vol. 86, no. 1, January 1978  
pp. 44-48.

Knowledge of apex seal temperature, gas pressure, combustion pressure, and other operating parameters is essential to further development of the rotary combustion engine. GM Research Labs has investigated rotary engine operation via a novel telemetry transmission system.

NASA CP-2067

1978

THE ROTARY COMBUSTION ENGINE - A CANDIDATE FOR  
GENERAL AVIATION. (Symposium held LeRC, Feb.  
28, 1978). 1978. 190p.

Symposium on the Rotary Combustion Feb. 28,  
Engine - A Candidate for General 1978  
Aviation

A WORLDWIDE ROTARY UPDATE  
Automotive Engineering  
Vol. 86, no. 2, February 1978,  
p. 31-42.

STRATIFIED CHARGE MIXING STRATEGIES COMPARED.  
C.D. Wood.

Automotive Engineering, v.86, no.8, Aug.1978, p.68-75.

Characteristics of five types of stratified charge combustion systems were evaluated in a recent study.

THE VARIABLE STROKE ENGINE: PROBLEMS AND PROMISES.  
D.C. Siegl and R.M. Siewert.

Automotive Engineering, v.86, no.8, Aug.1978, p.76-82.

Significant gains in fuel economy are possible from VSE's, but much work remains.

WHATEVER HAPPENED TO THE WANKEL ENGINE?  
Fritz Hirschfeld

Mechanical Engineering, Vol. 99, no. 5, May  
1977, p. 28-31

Curtiss-Wright—the original Wankel NSU licensee—has persevered in spite of a roller coaster history of ups and downs. Now, after 18 yr of development and an investment of almost \$40 million, it has begun to see some solid vindication of its faith. Ingersoll-Rand has adopted the Wankel design for its latest series of heavy-duty prime movers. And C-W has bet its chips on the stratified charge rotary engine.

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1976  
Stratified charge engines : conference /  
sponsored by the Automobile Division and  
the Combustion Engines Group, London, 23-  
25 November 1976. -- London ; New York :  
published by Mechanical Engineering Publica-  
tions for the Institution of Mechanical  
Engineers, 1977.  
187 p. : ill. -- (Conference publication  
1976 - 11)  
Includes bibliographies.

Effects of a Thermal Reactor  
on the Energy Efficiency of a  
Turbocharged, Stratified Charge  
Engine

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331

TJ  
210  
.S75  
v.2

Stratified charge engines, v.2. / edited by  
Frediano V. Bracco. -- London: Gordon and  
Beach, c1976.

111 p. : ill. ; 27 cm.

Cover title.

A collection of papers published in Com-  
bustion science and technology, v. 12, no.  
1/2/3.

1. Automobiles--Motors. I. Bracco, Fred-  
iano V., ed. II. Combustion science and  
technology. v. 12, nos. 1/2/3.

The concept of stratified charge is not new, indeed the possibility was mentioned by Otto himself as long ago as 1877, and engines embodying the principle were occasionally built and run in the early years of the present century. The present-day revival of interest in stratified charge is a direct outcome of current concern over atmospheric pollution and fuel economy. It has long been known that mixtures much leaner than those conventionally used can be burned if only they can be ignited; stratified charge offers a solution to the problem.

Much work has been put into the design of stratified charge engines and into fundamental research bearing upon the subject, and a conference at which the latest developments and progress could be reported and discussed therefore fulfilled a definite need. The conference was organized by the Automobile Division and the Combustion Engines Group of the Institution of Mechanical Engineers and held in London in November 1976. This book makes the papers presented at that conference available.

# AUTOMOTIVE POWERPLANTS - STRATIFIED CHARGE AND ROTARY

79N30262\*# ISSUE 21 PAGE 2778 CATEGORY 44  
79/08/15 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Comparison of two total energy systems for a diesel power generation plant --- deep space network

AUTH: A/CHAI, V. W.

CORP: Jet Propulsion Lab., California Inst. of Tech., Pasadena. CSS: (DSN Engineering Section.)

AVAIL.NTIS SAP: HC A06/MF A01

In Its The Deep Space Network p 89-93 (SEE N79-30248 21-12)

MAJS: /\*DEEP SPACE NETWORK/\*DIESEL ENGINES/\*ENERGY CONVERSION EFFICIENCY/\*GROUND STATIONS/\*HYDROELECTRIC POWER STATIONS

MINS: / AUSTRALIA/ ENERGY CONSERVATION/ SPAIN/ SYSTEMS ENGINEERING/ WASTE ENERGY UTILIZATION

ABA: M.M.M.

ABS: The capabilities and limitations, as well as the associated costs for two total energy systems for a diesel power generation plant are compared. Both systems utilize waste heat from engine cooling water and waste heat from exhaust gases. Pressurized water heat recovery system is simple in nature and requires no engine modifications, but operates at lower temperature ranges. On the other hand, a two-phase ebullient system operates the engine at constant temperature, provides higher temperature water or steam to the load, but is more expensive.

**TURBO-DIESEL BMW'S QUIET PERFORMER**, by Jan P. Norbye.

Popular Science, vol. 214, no. 4, April 1979, p.16-  
con't on 186.

79A33227# ISSUE 13 PAGE 2407 CATEGORY 44  
79/00/00 12 PAGES In PORTUGUESE UNCLASSIFIED DOCUMENT

UTTL: The development of alternate combustibles for diesel engines

AUTH: A/VENTURA, L. M. PAA: A/(Mercedes-Benz, Sao Paulo, Brazil)

In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. (A79-33212 13-44) Rio de Janeiro. Universidade Federal do Rio de Janeiro, 1979, p. 236-247. In Portuguese.

MAJS: /\*AUTOMOBILE FUELS/\*DIESEL FUELS/\*ETHYL ALCOHOL/\*FUEL OILS/\*GASOHOL (FUEL)

MINS: / BRAZIL/ DIESEL ENGINES/ ENERGY TECHNOLOGY/ VEGETABLES

ABA: J.M.B.

ABS: Ethanol, vegetable oils and blends of diesel oil and other combustibles have been considered for use in diesel engines. High-efficiency performance was found for diesel engines fueled by a mixture of diesel oil and vegetable oil. Blends of diesel oil and gasoline also proved promising for use in the diesel engine.

PRINT 11/2/96B

TERMINAL=33

79N77725# CATEGORY 45 RPT#: NTIS/PS-79/0039/2  
79/02/00 160 PAGES UNCLASSIFIED DOCUMENT

UTTL: Diesel exhaust emissions. Citations from the American Petroleum Institute data base TLSP: Progress Report, 1974 - Dec. 1978

AUTH: A/CAVAGNARO, D. M.

CORP: National Technical Information Service, Springfield, Va. AVAIL.NTIS SAP: HC \$28.00/MF \$28.00

MAJS: /\*AIR POLLUTION/\*BIBLIOGRAPHIES/\*DIESEL ENGINES/\* EXHAUST GASES/\*MOTOR VEHICLES

MINS: / ABSTRACTS/ HYDROCARBONS/ PUBLIC HEALTH/ SMOKE/ TOXICOLOGY



THE CONCEPT OF THE GENERALIZED THERMODYNAMIC  
ENGINE APPLIED TO CHEMICAL AND BIOCHEMICAL  
PROCESSES, I.D. Watson and A.C. Williamson

Jour. o Chem. Ed., v.56, no.11, Nov. 1979,  
p.723

*See subject reference person for this*

A simple definition of an engine is "a device in which energy is accepted in one form and transformed to another form in order to achieve some useful end." Usually, the useful end is some mechanical process such as the lifting of a weight or the rotation of a shaft. In this sense, the engine is an energy transducer. Frequently (though not always) it has two major components, a transducing medium or working fluid, and a mechanism whereby this working fluid is conducted through a cycle of transformations which brings about the desired energy conversion. We wish to illustrate, however, that other forms of energy transduction do occur and that certain biological and chemical processes can be viewed as transduction processes analogous to those taking place in the more familiar kinds of engine.

Environment, v.21, no.2, Mar.1979,

THE DIESEL DILEMMA

17

Lois Ember

By 1985 one out of every four new cars in the United States could be diesel powered—if the Environmental Protection Agency approves. The diesel engine is 25 percent more fuel efficient than today's gasoline engine, but it also emits fifty to eighty times as much soot. These tiny carbon particles not only create odor and visibility problems but may also pose a serious health risk. Before the end of this year, millions of dollars will be spent by both government and industry in trying to determine whether diesel fumes are in fact toxic enough to justify a ban on the future production of diesel cars.

79A33424# ISSUE 13 PAGE 2410 CATEGORY 44  
78/00/00 7 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Dynamics of a free-piston Diesel- MHD generator  
AUTH: A/BASHKATOV, V. A.; B/KIRILLOV, IU. M.; C/SAFONOVA,  
S. S.; D/SHEKOV, E. M.; E/SHPILRIN, E. E. PAA:  
E/(Akademiia Nauk SSSR, Nauchno-Issledovatel'skii  
Institut Vysokikh Temperatur, Moscow, USSR)

In: Symposium on the Engineering Aspects of  
Magnetohydrodynamics, 17th, Stanford, Calif., March  
27-29, 1978, Proceedings. (A79-33379 13-31) Stanford,  
Calif., Stanford University, 1978, p. H.8.1-H.8-7.

MAJS: /\*DIESEL ENGINES/\*MAGNETOHYDRODYNAMIC GENERATORS/\*  
PISTON THEORY/\*THERMODYNAMIC EFFICIENCY

MINS: / ELECTRIC POWER PLANTS/ ENERGY TECHNOLOGY/ LIQUID  
METALS

ABA: P.T.H.

ABS: Direct conversion of heat to electricity by a  
free-piston system consisting of Diesel drive and two  
conducting liquid metal MHD generators is analyzed.  
The dynamic characteristics of the system are  
calculated on the basis of a boundary value problem  
for the equation of motion of the centers of mass of  
the moving parts. It is shown that the efficiency of a  
free-piston Diesel-MHD generator can reach 34-36%.

NITINOL THERMODYNAMIC STATE SURFACES.

J.S. Cory.

J. Energy, v.2, no.5, Sept.-Oct.1978, p.257-58.

The engineering thermodynamics of Nitinol is one of the key elements of this technology. As shown by 150 years of heat engine experience, thermodynamics is vital for the efficient development of the technologies of system studies, invention, optimization, detailed design, and test evaluation of heat engines. To fulfill this role for Nitinol heat engines, historical experience shows that the engineering thermodynamics of Nitinol must 1) specify the necessary and sufficient state variables, 2) provide a quantitative description of all possible thermodynamic paths, together with 3) the work, 4) the heat flow, and 5) the energy dissipation associated with each of these paths. The purpose of this paper is to present an empirical data correlation which furnishes the first three requirements.

## ENERGY FROM HUMID AIR

T. K. Oliver W. N. Groves and C. L. Gruber  
and A. Cheung

J. of Energy

Vol. 2 no. 1 January -February 1978

p. 63-64

**A** VAST amount of energy is contained in the latent heat of vaporization of water vapor in humid air. This Note is a report on research in progress, the goal of which is to find a cost effective process to convert the energy in humid air into mechanical work. This would be used to drive an electrical generator. A proposed mechanization can be thought of as a heat engine with the air itself serving as the working fluid. The research is being carried out primarily by computer modeling.

## EFFICIENCY OF THE SOLID-STATE ENGINE MADE WITH NITINOL MEMORY MATERIAL.

Golestaneh, A.A.

J. Appl. Phys., v.49, no.3, Mar.1978, p.1241-1244.

The efficiency level of the heat-mechanical conversion based on the shape recovery of the memory materials is important in the development of a solid-state engine (SSE) that can operate with low-thermal-energy sources.<sup>1</sup> Unlike the Carnot engine, the efficiency of which depends only on the temperatures of the hot and cold reservoirs, the SSE efficiency depends on several parameters. To identify those factors that affect the efficiency, we have selected a two-stage operational cycle of the SSE generally in use.<sup>2</sup>

## MERCEDES TURBOCHARGES FIVE - CYLINDER DIESEL.

Kurt Oblander, Manfred Fortnagel, Hans -

Juergen Feucht, & Ulrich Conrad

Automotive Engineering, Vol. 86, No. 6, June 1978,  
p. 40-45

Significant gains in performance and economy result from application of a turbocharger to the Mercedes five-cylinder diesel powerplant.

TJ

153

.E4787

1978

Energy Technology Conference, 5th, Washington, D.C., 1978.

Energy technology V : challenges to technology : proceedings of the fifth Energy Technology Conference, February 27-March 1, 1978, Washington, D.C. / edited by Richard F. Hill. -- Washington : Government Institutes, 1978.

xiii, 1063 p. : ill.

1. Power (Mechanics)--Congresses.

SOLAR ENGINES: THE THERMAL WHEEL & BEYOND  
Arthur Crawford, Ralph L. Hough, Hough Laboratories

p. 675

LRC-69800

S- 462

THIS STEAM CAR WORKS....AND IT MEETS TOUGH '77  
EMISSION STANDARDS.

E.F. Lindsley.

Popular Science, Oct.1974, p.74,75,136

The Carter steamer uses new ways to harness steam  
with remarkable results.

Automotive Engineering, v.85, no.11, Nov.1977.

## Oldsmobile Opts for Diesel Power

The diesel passenger car is alive and well, and living in Lansing. Could this be the beginning of a trend making the full-size automobile more fuel-efficient?

24

77N24621# ISSUE 15 PAGE 2014 CATEGORY 44 RPT#:  
AD-A034180 USCG-D-113-76 76/08/00 13 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: The burn-off of waste lubricating oils in Coast Guard powerplants: Executive Summary  
AUTH: A/SHERRARD, J. R.; B/WALTER, R. A.  
CORP: Transportation Systems Center, Cambridge, Mass.  
AVAIL:NTIS SAP: HC A02/MF A01  
Sponsored in part by the Coast Guard  
MAJS: /\*COMBUSTION/\*DIESEL ENGINES/\*LUBRICATING OILS  
MINS: / FEASIBILITY ANALYSIS/ FUEL CONSUMPTION/ GAS TURBINES / OIL POLLUTION  
ABA: Author (GRA)  
ABS: This report summarizes the results of a study to investigate the feasibility of utilizing waste lubricating oils as fuel in Coast Guard powerplants.

Adoption of this practice by the Coast Guard would conserve diesel fuel, as well as minimizing environmental degradation and eliminating costs associated with lube oil disposal. It was concluded that the Coast Guard can safely use this lube oil as fuel if it is properly filtered and mixed at the correct ratios with the fuel oil. Various filtering devices were tested and the correct mix ratios for diesel engines, boilers, and gas turbines were determined. It was found that with these safeguards the practice of lube oil burn-off will not adversely affect engine emissions, performance, maintenance, or wear characteristics. Final recommendations and conclusions were made to the Coast Guard for the adoption of this practice.

77X74504# CATEGORY 44 RPT#: AD-B016354L  
APG-MT-4861 76/09/00 2 VOLS 167 PAGES  
UNCLASSIFIED DOCUMENT GOVT. AGCY

UTTL: Development test 3 of generator set, 10-KW, 60-hertz, air-cooled, diesel-engine-driven TLSP: Final Report, 14 Jan. - 13 Jul. 1976  
AUTH: A/ARMACOST, G. R.  
CORP: Aberdeen Proving Ground, Md. CSS: (Materiel Testing Directorate.)  
MAJS: /\*AIR COOLING/\*DIESEL ENGINES/\*ELECTRIC GENERATORS  
MINS: / COOLING SYSTEMS/ EQUIPMENT SPECIFICATIONS/ PERFORMANCE TESTS

77X74505# CATEGORY 44 RPT#: AD-B016357L  
APG-MT-4860 76/09/00 2 VOLS 187 PAGES  
UNCLASSIFIED DOCUMENT GOVT. AGCY

UTTL: Development test 3 of generator set, 5-KW, 60-hertz, air-cooled, diesel-engine-driven TLSP: Final Report, 14 Jan. - 13 Jul. 1976  
AUTH: A/ARMACOST, G. R.  
CORP: Aberdeen Proving Ground, Md. CSS: (Materiel Testing Directorate.)  
MAJS: /\*AIR COOLING/\*DIESEL ENGINES/\*ELECTRIC GENERATORS  
MINS: / COOLING SYSTEMS/ EQUIPMENT SPECIFICATIONS/ PERFORMANCE TESTS

78N77916# CATEGORY 44 RPT#: PB-277188 TE4186-27-75  
NSF/RA/N-74-287 CNT#: NSF GI-40774 74/11/00 407 PAGES UNCLASSIFIED DOCUMENT

UTTL: High efficiency decentralized electrical power generation utilizing diesel engines coupled with organic working fluid rankine-cycle engine operating on diesel reject heat  
AUTH: A/MORGAN, D. T.; B/DAVIS, J. P.  
CORP: Thermo Electron Corp., Waltham, Mass. AVAIL:NTIS  
MAJS: /\*DIESEL ENGINES/\*ELECTRIC POWER SUPPLIES/\*RANKINE CYCLE/\*WASTE ENERGY UTILIZATION  
MINS: / COAL GASIFICATION/ ENERGY CONSERVATION/ ENVIRONMENT EFFECTS/ FUEL OILS/ LAND USE/ NATURAL GAS/

XIV. ENERGY STORAGE . . . . .	1123
A. General . . . . .	1124
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D. Thermal . . . . .	1168
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G. Magnetic . . . . .	1225



## ENERGY STORAGE - GENERAL

BON14546# ISSUE 5 PAGE 624 CATEGORY 44 RPT#:  
SERI/TP-34-089 CNT# 16-77-C-01-4042 79/03/00 123  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Thermal energy storage for solar applications: An overview

AUTH: A/WYMAN, C.

CORP: Midwest Research Inst., Golden, Colo. AVAIL NTIS

SAP: HC A06/MF A01

MAJS: /\*ENERGY TECHNOLOGY/\*HEAT STORAGE/\*SOLAR HEATING

MINS: / COST ANALYSIS/ ENERGY STORAGE/ TECHNOLOGY ASSESSMENT

ABA: DOE

ABS: The economic role of storage for solar home heating and stand-alone electric plants are examined. Factors which affect the economics of storage are discussed. The costs and storage capacities of representative sensible and latent heat storage materials are summarized. Various modes of operation are also presented for thermal storage by reversible chemical reactions. Containers and heat exchangers are reviewed to illustrate possible approaches to reducing storage costs. Reversible reaction storage, and gas-solid reactions are shown to have desirable attributes for solar energy storage.

### ENERGY-STORAGE SYSTEMS

Fritz R. Kalhammer

Scientific American, vol. 241 no. 6, Dec. 1979, pp. 56-65.

Energy reservoirs consisting of pumped water, compressed air, batteries and ways of storing heat and "cold" can do much to help coal, nuclear and solar energy replace substantial quantities of oil.

79N33592# ISSUE 24 PAGE 3230 CATEGORY 44 RPT#:  
PB-295936/9 ISBN-91-540-2955-4 79/00/00 162 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Storage of heat: A survey of efforts and possibilities

AUTH: A/WETTERMARK, G.; B/CARLSSON, B.; C/STYMNE, H.

CORP: Swedish Council for Building Research, Stockholm

AVAIL NTIS SAP: HC A06/MF A01

MAJS: /\*ENERGY TECHNOLOGY/\*HEAT STORAGE/\*SOLAR HEATING

MINS: / PHASE TRANSFORMATIONS/ SOLAR ENERGY CONVERSION/ THERMOCHEMISTRY

ABA: GRA

ABS: Various methods are described for storing heat. Topic areas discussed include the following: the role of heat storage in different energy systems; heat storage with passive and active solar heat systems; sensible heat; latent heat - phase change; thermochemical reactions; the American program for storage of heat.

### ON THE ECONOMIC ASSESSMENT AND OPTIMIZATION OF ENERGY STORAGE SYSTEMS

H. Davitian and R. W. Leigh

Energy, vol. 4, no. 6, Dec. 1979, pp. 1099-1105.

**Abstract**—A method is described for the economic optimization and comparative evaluation of various energy storage systems in a given application. The method is particularly useful in examining the economics of devices with short lifetimes and can be employed whenever a device lifetime can be expressed as a function of physical parameters which are related to the manner in which the device is used. Given a detailed description of the pattern of use of the device in the application, the device lifetime can be calculated. The economic consequences of changes in lifetime result from the dependence of the capital recovery factor on device lifetime. It is shown how analyses can be made of changes in technical performance characteristics or changes in the pattern of use of the storage device to determine their effects upon the annual cost of energy storage and to determine minimum cost systems.

79A37873 ISSUE 15 PAGE 2791 CATEGORY 44  
79/00/00 9 PAGES UNCLASSIFIED DOCUMENT

UTTL: Batteries, fuel cells, a hydrogen economy - Keynote address

AUTH: A/BARAK, M.

In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979. Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 177-185

MAJS: /\*ELECTRIC BATTERIES/\*FUEL CELLS/\*HYDROGEN-BASED ENERGY

MINS: / ENERGY POLICY/ ENERGY TECHNOLOGY/ HYDROGEN OXYGEN FUEL CELLS/ LITHIUM SULFUR BATTERIES/ METAL AIR BATTERIES/ METAL HALIDES/ SODIUM SULFUR BATTERIES/ THERMODYNAMIC EFFICIENCY/ ZINC-OXYGEN BATTERIES

ABA: B.J.

ABS: Basic principles of batteries and fuel cells are considered and attention is given to common cells and batteries with aqueous electrolyte and properties of

materials for cathodes and anodes. Attention is then given to the following types of cells, in the R&D stage or in pilot plant production: cells with lithium anodes, metal-air cells, metal-halogen cells, and high temperature batteries. The properties and applications of fuel cells are briefly reviewed and consideration is given to the possibilities of a hydrogen economy.

**A80-11979** Overview of division of energy storage program - Department of energy. G. F. Pezdirtz (U.S. Department of Energy, Div. of Energy Storage Systems, Washington, D.C.). In: Energy technology VI: Achievements in perspective; Proceedings of the Sixth Conference, Washington, D.C., February 26-28, 1979. (A80-11953 02-44) Washington, D.C., Government Institutes, Inc., 1979, p. 896-903.

The division of Energy Storage Systems of the U.S. Department of Energy was created in order to develop and seek out applications for new and more efficient energy storage techniques. The paper reviews the activities of the division from the point of view of the diversity of central and dispersed energy storage applications. The potential energy savings of the various forms of energy storage under consideration are outlined, and a timetable for the commercialization of energy storage batteries, chemical and thermal systems and physical methods is presented. Particular attention is given to programs investigating compressed air and battery storage for utility load leveling, thermal energy storage for industrial waste heat, aquifer storage of cooled water, the electrolytic production of hydrogen using low-head hydroelectric power, customer-owned thermal energy storage, lead-acid, nickel zinc, nickel iron, sodium sulfur, lithium/metal sulfide and aluminum air batteries and flywheel energy storage for electric vehicles and gasoline/electric hybrid vehicles. A.L.W.

79A44959 ISSUE 19 PAGE 3624 CATEGORY 44  
79/04/00 3 PAGES In GERMAN UNCLASSIFIED DOCUMENT

UTTL: Energy storage --- survey of recent R and D

AUTH: A/KAIER, U. PAA: A/(Kraftanlagen AG, Heidelberg, West Germany)

Brennstoff-Waerme-Kraft, vol. 31, Apr. 1979, p. 150-158. In German.

MAJS: /\*ENERGY STORAGE/\*ENERGY TECHNOLOGY/\*RESEARCH AND DEVELOPMENT/\*TECHNOLOGY ASSESSMENT

MINS: / DOMESTIC ENERGY/ ELECTRIC POWER/ HEAT STORAGE/ HYDROGEN-BASED ENERGY/ STORAGE BATTERIES

ABA: M.E.P.

ABS: Various methods of energy storage are surveyed. Systems are described according to type of application and working medium. Attention is given to the three areas in which R&D is being undertaken: (1) energy storage in systems for electricity and power generation, (2) central heat storage for heating from remote sources, (3) decentralized small heat reservoirs in the household area. In addition, the operating economy of several systems of energy storage such as thermal oil, steam, hydrogen, and flywheel, are detailed.

**N80-10643#** Rensselaer Polytechnic Inst., Troy, N. Y. Cogswell Lab.

**PHYSICAL PROPERTIES DATA COMPILATIONS RELEVANT TO ENERGY STORAGE. 2. MOLTEN SALTS: DATA ON SINGLE AND MULTI-COMPONENT SALT SYSTEMS**

G. J. Janz, C. B. Allen, N. P. Bansal, R. M. Murphy, and R. P. T. Tomkins Apr. 1979 440 p refs

(Contract W-7405-eng-48)

(NSRDS-NBS-61-Pt-2; LC-77-10824)

HC A19/MF A01

Avail: NTIS

The work provides selected data with value judgments for a set of 49 salt systems of interest as candidate materials for thermal energy storage sub-systems and for electrochemical energy storage systems. The physical properties assessed are melting points; phase diagrams; eutectic compositions; density; surface tension; viscosity; electrical conductivity; diffusion for ions; heat of fusion; heat capacity; volume change on fusion; vapor pressure; thermal conductivity (liquid and solid); and cryoscopic constant. The status of corrosion studies in the form of annotated bibliographic summaries, and salient observations on safety and hazards are also reported. A summarizing series of tables are provided as index to the data-gaps status for this set of candidate materials.

DOE

# ENERGY STORAGE, COMPRESSION, AND SWITCHING

W. H. Bostick, V. Nardi, and O. F. S. Zucker

The need for very short and high-powered electron-beam pulses, laser pulses, and high-current pulses has brought forth a new technology, which can be consciously identified as the process of energy compression. This technology is based on the storage and switching of these forms of energy. All the major world powers make extensive use of this new science in their pulsed CTR and weapons simulation programs.

79A15866# ISSUE 4 PAGE 643 CATEGORY 44  
78/04/00 12 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Latent heat storage techniques  
AUTH: A/TELKES, M. PAA: A/(American Technological University, Killeen, Tex.)  
Institute of Gas Technology, Energy from the Sun Symposium, Chicago, Ill., Apr. 3-7, 1978, Paper, 12 p.  
MAJS: /\*FUSION (MELTING)/ \*HEAT STORAGE/ \*SOLAR HEATING/ \*THERMOPHYSICAL PROPERTIES  
MINS: / CHLORIDES/ ENTHALPY/ HEAT OF VAPORIZATION/ HYDRATES/ HYDROCARBON COMBUSTION/ SPECIFIC HEAT/ WATER  
ABA: (Author)  
ABS: The latent heat of fusion or transition of compounds, alloys or eutectics can be calculated from the entropies of fusion of elements forming them. Observed and calculated values are compared to show the accuracy of this method. Latent heat storage materials must meet performance criteria of high heat of fusion per unit weight and volume and low expansion during melting. The obvious requirements must be maintained, using only those materials that are non-combustible, do not explode, are not toxic, caustic or corrosive. Examples of higher temperature materials are shown in graph form. Salt hydrates are economically and technically most suitable for solar heat storage. Increasing the efficiency of gas-heated domestic furnaces is feasible by storing a major part of the heat, discharged in combustion gases through the stack or chimney.

A79-44959 Energy storage (Energiespeicherung). U. Kaier (Kraftanlagen AG, Heidelberg, West Germany). Brennstoff-Wärme-Kraft, vol. 31, Apr. 1979, p. 156-158. 53 refs. In German.  
Various methods of energy storage are surveyed. Systems are described according to type of application and working medium. Attention is given to the three areas in which R&D is being undertaken: (1) energy storage in systems for electricity and power generation, (2) central heat storage for heating from remote sources, (3) decentralized small heat reservoirs in the household area. In addition, the operating economy of several systems of energy storage such as thermal oil, steam, hydrogen, and flywheel, are detailed. M.E.P.

79A34132 ISSUE 13 PAGE 2425 CATEGORY 44  
78/00/00 20 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Direct contact heat exchange for latent heat-of-fusion energy storage systems  
AUTH: A/NICHOLS, M. C.; B/GREEN, R. M. PAA: B/(Sandia Laboratories, Livermore, Calif.)  
In: Alternative energy sources: Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9. (A79-34131 13-44)  
Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3939-3958.  
MAJS: /\*FUSION (MELTING)/ \*HEAT EXCHANGERS/ \*HEAT STORAGE/ \*HEAT TRANSFER/ \*LIQUID-SOLID INTERFACES  
MINS: / COLUMNS (PROCESS ENGINEERING)/ ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY/ PARAFFINS/ PERFORMANCE PREDICTION/ PHASE TRANSFORMATIONS/ WATER HEATING/ WORKING FLUIDS  
ABA: S.D.  
ABS: A computational-experimental work is performed to assess the feasibility of the 'shot tower' latent heat of fusion energy storage concept. The shot tower system uses mutually immiscible heat-transfer-fluid/phase-change-material pairs of different density in such a way that both the heat transfer fluid and the phase change material move. It is shown that a shot-tower-type heat exchanger using water/paraffin and having a length of about 2 m and a diameter of about 25 cm can extract heat from a tank of molten paraffin at a rate sufficient to supply domestic hot water to about ten families.



79H11535# ISSUE 2 PAGE 207 CATEGORY 44 RPT#:  
HCP/T22221-01/3 CNI#: NSF C-75-22221-01 72/01/00  
330 PAGES UNCLASSIFIED DOCUMENT

UTTL: Applied research on energy storage and conversion for  
photovoltaic and wind energy systems. Volume 3: wind  
conversion systems with energy storage TLSP: Final  
Report

CORP: General Electric Co., Philadelphia, Pa. CSS: (Space  
Div.) AVAIL: NTIS SAP: HC A15/MF A01  
Sponsored in part by DOE

MAJS: /ENERGY STORAGE/\*PHOTOVOLTAIC CONVERSION/\*WINDPOWER  
UTILIZATION

MINS: / COST ANALYSIS/ ENERGY TECHNOLOGY/ UTILITIES/ WIND  
VARIATIONS

ABA: DOE

ABS: Energy storage technologies deemed best suited for use  
in conjunction with a wind energy conversion system in  
utility, residential and intermediate applications  
were evaluated. Break-even cost goals are presented  
for several storage technologies in each application.  
These break-even costs are compared with cost  
projections to show technologies and time frames of  
potential economic viability. Results, conclusions and  
recommendations pertaining to use of energy storage  
with wind energy conversion systems are included.

MATERIALS PROBLEMS IN SOLAR AND NUCLEAR ENERGY  
AND STORAGE OF ENERGY, by R. S. Claassen.  
Sampe Quarterly, vol. 10, no. 1, October 1978,  
p. 27-35.

Typical examples are provided to illustrate the intimate relationship of materials and processing to the energy program. Developing energy technologies place increasing demand on material performance and in some cases exceed known material capabilities. Material choices in solar systems are dominated by cost; distributed collectors and the central receiver illustrate practical problems. The demand for absolute safety in nuclear power requires a depth of understanding and level of knowledge about materials unachieved in previous engineering systems; problems in water-cooled and breeder reactors emphasize the point. Fusion reactors will push far beyond our present knowledge of material response and behavior. Within limits, energy storage is practical today but present technologies such as batteries are being pushed hard and new schemes such as superconducting solenoids and thermochemical storage are under intense study.

## PHOTOCHEMICAL STORAGE OF SOLAR ENERGY

J.R. Bolton

Solar Ener., v. 20, no.2, 1978, p.181-183

Solar energy is an immense energy resource as each year the earth receives about 5400 Q<sup>1</sup> of energy. The estimated available fossil fuel reserves on earth total only about 200 Q[1], or about two weeks of the total solar input. However, solar energy suffers from two disadvantages—it is intermittent and varies considerably with the seasons, and it is widely distributed and hence its energy density at any one place is not high. Thus energy storage and large areas of collectors are important requirements for the utilization of solar energy. Nature has solved both of these problems and for billions of years has been using and storing solar energy through photosynthesis, the natural process of photochemical solar energy storage. It is estimated[2] that each year about  $5 \times 10^{10}$  tonnes of carbon are fixed through photosynthesis. This represents a storage of about 20 Q per year or about 0.4 per cent. of the world's yearly solar input. Looked at from another aspect the storage of solar energy via photosynthesis is occurring at a rate over 50 times the current rate of world consumption of energy by man. Unfortunately, with the exception of wood, most of the products of photosynthesis are not in a convenient form for use by man as an energy source.

ENERGY STORAGE: HOW DO YOU PRESERVE WATTS AND BTU?  
Robert B. Aronson  
Machine Design  
Vol. 50 no. 1 January 12, 1978, p.30-32.

The search is on for more effective ways to store and recover heat and electricity. If successful, the payoff will be large-scale fuel savings. The electric utilities' need for inefficient peak-power generators could be eliminated; significant amounts of energy from new power systems, such as solar cells and windmills, could be obtained; and the electric vehicle could become more appealing as an alternative to gasoline-powered transportation.



78A28164 ISSUE 10 PAGE 1795 CATEGORY 44  
78/00/00 11 PAGES UNCLASSIFIED DOCUMENT

UTTL: Comparisons of deep well and insulated shallow earth storage of solar heat

AUTH: A/NICHOLLS, R. L. PAA: A/(Delaware, University, Newark, Del.)

Solar Energy, vol. 20, no. 2, 1978, p. 127-137.

MAJS: /\*HEAT EXCHANGERS/\*HEAT STORAGE/\*SOLAR ENERGY CONVERSION/\*SOLAR HEATING/\*WELLS

MINS: / AQUIFERS/ ENERGY TECHNOLOGY/ HEAT TRANSMISSION/ RADIAL FLOW/ THERMAL DIFFUSION/ TUBE HEAT EXCHANGERS/ WATER CIRCULATION

ABA: (Author)

ABS: Four techniques for storing solar heat in earth are described and their costs are compared by a hypothetical example. They include heat storage by: (a) deep well; (b) deep well with a storage membrane; (c) insulated shallow earth heat exchange bed; and (d) insulated shallow earth tube exchanger. The cost comparison obtains optimal design parameters for each storage method and optimal surface area for an attached solar collector. Heat loss equations for insulated shallow earth storage are obtained by electrolytic tank models. Heat loss for deep well storage is derived by superposition of radial flow of water and diffusion of heat.

TJ Energy Technology Conference, 5th, Washington,  
153 D.C., 1978.

.E4787 Energy technology V : challenges to  
1978 technology : proceedings of the fifth  
Energy Technology Conference, February 27-  
March 1, 1978, Washington, D.C. / edited by  
Richard F. Hill. -- Washington : Government  
Institutes, 1978.

xiii, 1063 p. : ill.

MATERIALS PROBLEMS IN SOLAR, NUCLEAR AND STORAGE OF ENERGY  
Richard S. Claessen, Director of Materials & Processes Organization, Sandia Laboratories

p. 540

LC-69800

BON10623# ISSUE 1 PAGE 86 CATEGORY 44 RPT#:  
UCRL-15005 CNT# W-7405-ENG-48 78/00/00 61 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Methods of estimating the reliability of wind energy systems with storage

AUTH: A/GLASSEY, C. R.; B/MOYER, G. F.

CORP: California Univ., Livermore, Lawrence Livermore Lab.  
AVAIL NTIS SAP: HC A05/MF A01

MAJS: /\*ENERGY STORAGE/\*ENERGY TECHNOLOGY/\*WINDPOWER UTILIZATION/\*WINDPOWERED GENERATORS

MINS: / ESTIMATES/ MATHEMATICAL MODELS/ PERFORMANCE/ RELIABILITY ANALYSIS

ABA: DOE

ABS: Some preliminary results obtained in analyzing the reliability of wind generator storage systems are presented. The investigation took two separate approaches, simulation and probabilistic modeling, to reveal the trade-offs which can be made between generating capacity and storage capacity to attain a desired level of reliability. The performance criterion used throughout this work was the frequency of occurrence of empty storage. This criterion was essentially the same as the frequency of loss of load.

TJ Energy Technology Conference, 5th, Washington,  
153 D.C., 1978.

.E4787 Energy technology V : challenges to  
1978 technology : proceedings of the fifth  
Energy Technology Conference, February 27-  
March 1, 1978, Washington, D.C. / edited by  
Richard F. Hill. -- Washington : Government  
Institutes, 1978.

LARGE-SCALE THERMAL ENERGY STORAGE FOR  
COGENERATION AND SOLAR SYSTEMS p. 178  
Charles F. Meyer, Technical Staff, General Electric Company -- TEMPO

STORAGE AS AN ENERGY STRATEGY FOR UTILITIES p. 379  
Thomas R. Schneider, Program Manager, Energy Storage, Electric Power Research Institute

LC-67800

Energy Conversion, v.18, 1978, p.121-125.  
**ENERGY STORAGE: ECONOMICS  
AND FUEL CONSERVATION**

**A. A. DE BOER and J. SMIT**

ECN-Netherlands Energy Research Foundation, Research Centre,  
3 Westerduinweg, Petten (NH), The Netherlands

(Received 1 February 1978)

**Abstract** This article presents an analysis of the economic aspects of energy storage for an electric utility. It is shown that it is possible to optimize the storage economics. A relation between the efficiency of an energy storage device and the possible fuel saving is derived. Fuel savings are only obtainable with high efficiency energy storage systems.

**N79-24509#** Brookhaven National Lab., Upton, N. Y. National Center for Analysis of Energy Systems.

**METHOD FOR THE COMPARATIVE ECONOMIC ASSESSMENT OF ENERGY STORAGE SYSTEMS**

H. Davitian and R. W. Leigh. Nov 1978. 18 p. refs. Presented at Intersoc. Energy Conversion Eng. Conf., San Diego, Calif., Oct. 1978.

(Contract EY-76-C-02-0016)

(BNL-25291; Conf-7810142-1)

Avail: NTIS

HC A02/MF A01

A method for the comparative economic evaluation of various energy storage devices in a given application is outlined. The method is used in examining the economics of devices with short lifetimes and can be employed whenever a device lifetime can be expressed as a function of physical parameters which are related to the manner in which the device is used. The economic consequences of changes in lifetime result from the dependence of the capital recovery factor on device lifetime. It is shown how analyses can be made of changes in technical performance characteristics or changes in the pattern of use of the storage device to determine their effects upon the annual cost of energy storage and to determine minimum cost systems.

DOE

**N80-10970#** California Univ., Livermore. Lawrence Livermore Lab.

**ENERGY STORAGE SYSTEMS FOR AUTOMOBILE PROPULSION, 1978 STUDY. 1: OVERVIEW AND FINDINGS**

C. J. Bertram, C. J. Anderson, H. Bomelburg (Battelle Pacific Northwest Labs.), M. Farahat (Argonne National Lab.), H. C. Forsberg, C. L. Hudson (Interplan Corp.), B. C. Kullman (Cambridge Systematics, Inc., Mass.), L. G. O'Connell, G. Strickland (Brookhaven National Lab.), and W. J. Walsh. 15 Dec. 1978. 57 p. refs.

(Contract W-7405-eng-48)

(UCRL-52553-Vol-1) Avail: NTIS HC A04/MF A01

Technical and cost analyses were made of electrochemical, mechanical, chemical, and thermal storage devices and power systems which are likely to provide credible alternatives to current and future internal combustion engine propulsion systems between now and the year 2000. These devices were used in conceptual designs of various energy storage propulsion systems. Their resultant performances and costs were calculated and compared against each other and against a baseline ICE vehicle system conceptually designed to provide the same performance. Aspects of concern were the effect on all-battery electric systems of optimizing batteries for the specific peak power and specific energy relationship, the effect on the relative results of using highly optimistic (10% confidence level) component characteristics; the national energy impact of the future introduction of energy storage automobiles; and the effect on prior results and conclusions of R and D achievements in the past year. DOE

**A79-10241\*** **SIMWEST - A simulation model for wind energy storage systems.** R. W. Edsinger, A. W. Warren (Boeing Computer Services, Inc., Seattle, Wash.), L. H. Gordon (NASA, Lewis Research Center, Cleveland, Ohio), and G. C. Chang (U.S. Department of Energy, Washington, D.C.). In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings, Volume 3. (A79-10001 01-44) Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 2108-2114.

This paper describes a comprehensive and efficient computer program for the modeling of wind energy systems with storage. The level of detail of SIMWEST (Simulation Model for Wind Energy Storage) is consistent with evaluating the economic feasibility as well as the general performance of wind energy systems with energy storage options. The software package consists of two basic programs and a library of system, environmental, and control components. The first program is a precompiler which allows the library components to be put together in building block form. The second program performs the technoeconomic system analysis with the required input/output, and the integration of system dynamics. An example of the application of the SIMWEST program to a current 100 kW wind energy storage system is given.

(Author)

79A34004 ISSUE 13 PAGE 2413 CATEGORY 44  
78/00/00 10 PAGES UNCLASSIFIED DOCUMENT

UTTL: Modular stackable hot water storage/heat exchanger system for solar installations  
AUTH: A/MELROY, P. J.; B/SPENCER, D. L. PAA: A/(Kirkwood Community College, Cedar Rapids, Iowa); B/(Iowa, University, Iowa City, Iowa)  
In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 2. (A79-34002 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978. p. 561-570.  
MAUS: /\*ECONOMIC ANALYSIS/\*HEAT EXCHANGERS/\*HEAT STORAGE/\*SOLAR HEATING/\*WATER HEATING  
MINS: / CHANNEL FLOW/ LOW COST/ PRESSURE GRADIENTS/ SOLAR CELLS/ STORAGE TANKS/ TEMPERATURE DISTRIBUTION

#### ENERGY STORAGE AND SOLAR POWER: AN EXAGGERATED PROBLEM

William D. Metz

Science, v.200, no.4349, June 30, 1978, pp.1471-1473

Solar energy storage is a complex problem, and the importance of storage—especially for uses in the near- and intermediate-term future—may be overstressed and misunderstood.

N80-12596# California Univ., Livermore. Lawrence Livermore Lab.

#### MECHANICAL ENERGY STORAGE TECHNOLOGY DEVELOPMENT FOR ELECTRIC AND HYBRID VEHICLE APPLICATIONS

T. M. Barlow 17 Oct. 1978 10 p refs Presented at 1st Inform. Exchange Conf., Luray, Va. 24 Oct. 1978 (Contract W-7405-eng-48)  
(UCRL-81786; CONF-781048-11) Avail. NTIS HC A02/MF A01

Flywheel concepts and one elastomeric energy storage concept all applicable to regenerative braking are developed. The performance and fuel economy of electric vehicles are improved. An experimental study of the effect of load leveling on battery life and analytical evaluations of mechanical energy storage technology are included. These activities are integrated in an overall plan and management structure designed to enhance the commercialization of electric vehicles DOE

SAIPE Quarterly, v.10, no.1

Oct.  
1978

#### MATERIALS APPLICATIONS IN ADVANCED ENERGY SYSTEMS. Special Issue - 10th Anniversary Issue)

#### MATERIALS PROBLEMS IN SOLAR AND NUCLEAR ENERGY AND STORAGE OF ENERGY.....27

R. S. Claassen

A78-20788 # Mechanical energy storage systems - Compressed air and underground pumped hydro. H. H. Chiu, L. W. Rodgers, Z. A. Saleem, R. K. Ahluwalia (Illinois, University, Chicago, Ill.), G. T. Kartsounes, and F. W. Ahrens (Argonne National Laboratory, Argonne, Ill.). American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting 16th, Huntsville, Ala., Jan. 16-18, 1978, Paper 78-281. 15 p. 38 refs. ERDA-supported research.

Compressed air and underground pumped hydro storage are near-term load-leveling and peak-shaving technologies that are being considered by electric utilities. Assessments of the technical and economic feasibility of these storage systems have concluded that no major technical barriers for their implementation exist and that the systems are economically competitive with conventional peaker plants. This paper reviews and compares the characteristics of these two energy storage systems, evaluates their potential impacts, and presents recent research results with particular emphasis on air storage technology. In addition, advanced concepts and technical areas, where further work would be beneficial, are discussed.

(Author)

A79-40746 # Photochemical aspects of solar energy conversion and storage. J. R. Bolton (Western Ontario, University, London, Canada). In: Chemistry for energy; Proceedings of the Symposium, Winnipeg, Manitoba, Canada, June 5-7, 1978. (A79-40736 17-44) Washington, D.C., American Chemical Society, 1979, p. 202-220. 40 refs.

The paper defines qualitatively and quantitatively the thermodynamic and kinetic limits on the photochemical conversion and storage of solar energy as it is received on the earth's surface. Attention is given to an evaluation of a number of possible reactions, with special emphasis on the generation of solar fuels such as hydrogen from water and the generation of electricity. The photochemical reactions leading to the conversion and storage of solar energy are divided into five types: molecular energy storage reactions, homolytic bond fission reactions, homogeneous redox reactions for generation of solar fuels, photoelectrochemical generation of solar fuels, and photochemical systems designed to generate electricity. It is shown that a reasonable efficiency goal would be about 25-28% for conversion to electricity and about 10-13% for storage as chemical energy. S.D.

78A27860 ISSUE 10 PAGE 1793 CATEGORY 44  
77/00/00 16 PAGES UNCLASSIFIED DOCUMENT

UTTL: Solar pond

AUTH: A/SAVAGE, S. B. PAA: A/(McGill University, Montreal, Canada)

In: Solar energy engineering. (A78-27852 10-44) New York, Academic Press, Inc., 1977, p. 217-232.

MAJS: /\*ENERGY CONVERSION EFFICIENCY/\*HEAT EXCHANGERS/\*HEAT STORAGE/\*SOLAR PONDS (HEAT STORAGE)/\*WATER FLOW

MINS: / ENERGY TECHNOLOGY/ RECIRCULATIVE FLUID FLOW/ RECYCLING/ SHALLOW WATER/ SOLAR COLLECTORS/ WATER TEMPERATURE

ABA: G.R.

ABS: It has been proposed that nonconvective solar ponds should be used for collecting and storing energy on a large scale. A solar pond is a shallow body of water about one meter deep containing dissolved salts to generate a stable density gradient with fresh water on top and denser salt water at the bottom. Part of the incident solar radiation entering through the pond surface is absorbed throughout the depth. The remainder which penetrates the pond is absorbed at the black bottom. The density gradient is used to suppress convection. Heat is, therefore, lost from the lower layers only by conduction. Energy can be extracted from the pond by recycling the water in the hot layers of the pond through a heat exchanger. A review is conducted concerning the previous work on solar ponds, taking into account the physical principles of their operation and the practical difficulties which would have to be overcome.

A78-38428 Pneumatic energy storage in flexible, gas-filled composites. D. R. Otis (Wisconsin, University, Madison, Wis.). *Arabian Journal for Science and Engineering*, vol. 3, Nov. 1977, p. 57-59.

Mechanical means of storing energy, e.g., flywheels, springs, weight-pulley systems, compressed gas, etc., are evaluated with attention to pneumatic energy storage in flexible, gas-filled composites. In the proposed scheme, energy is collected over a short period of time, stored over a long period, and used again over a short period. An experiment devised to test the concept is described, whereby a compression volume is filled with a gas-filled substance such as a foamed elastomer, whose pore size permits close thermal contact between the gas and the solid. Compression is isothermal and heat loss during storage is small. Virtually all the work of compression is thus recoverable by expanding the gas. D.M.W.

78A11305 ISSUE 1 PAGE 73 CATEGORY 44 77/00/00  
5 PAGES UNCLASSIFIED DOCUMENT

UTTL: A numerical simulation of heat transfer in rock beds

AUTH: A/ESHLEMAN, W. D.; B/BAIRD, C. D.; C/MEARS, D. R.

PAA: B/(Florida, University, Gainesville, Fla.);

C/(Cook College, New Brunswick, N.J.)

In: International Solar Energy Society, Annual Meeting, Orlando, Fla., June 6-10, 1977, Proceedings, Sections 14-25. (A78-11212 01-44) Cape Canaveral, Fla., International Solar Energy Society, 1977, p. 17-21 to 17-25.

MAJS: /\*BEDS (GEOLOGY)/\*CONVECTIVE HEAT TRANSFER/\*DIGITAL SIMULATION/\*HEAT STORAGE/\*ROCKS

MINS: / FLOW CHARTS/ HEAT TRANSFER COEFFICIENTS/ SOLAR COLLECTORS/ SOLAR ENERGY CONVERSION

ABA: R.D.V.

ABS: A numerical packed bed heat exchange model originally developed for application to heat transfer from beds of fruit and vegetables is modified for application to beds of rock. The model is recommended for working out guidelines for analysis and design of rock beds to serve as heat reservoirs for storage and controlled release of heat. A technique for determining bed convective heat transfer coefficients is included, and simulation of simplified solar collector and of a process load returning constant-temperature air to collector and storage is described.

## THE USE OF FUNCTIONALIZED POLYMERS AS PHOTOSENSITIZERS IN AN ENERGY STORAGE REACTION

Richard R. Hautala, James Little and Edward Sweet

Solar Energy

Vol. 19, no. 5, 1977, p. 503-508

Abstract—Insoluble polymer bound photosensitizers, useful for the conversion of norbornadiene (1) to quadricyclene (2), have been synthesized. An acetophenone analogue was produced by Friedel-Crafts acylation of polystyrene resin while treatment of chloromethylated resin with salicylaldehyde and triethylamine produced an analogue of benzyloxybenzaldehyde. Reaction of lithio-polystyrene resin with methyl 4-(N,N-dimethylamino)benzoate gave a ketone equivalent to 4-(N,N-dimethylamino)benzophenone (3). Quantum yields for the conversion of 1 and 2 using the polymer bound sensitizers were generally comparable to, but slightly lower than, the analogous compound in homogeneous solution. The quantum yield of polymer bound 3 was less solvent dependent than that of the homogeneous counterpart. The advantages of isolating the photosensitizer to the photochemical reactor stage of a photochemical solar energy storage device are discussed.



77A50208 ISSUE 24 PAGE 4185 CATEGORY 44 CNT#:  
E(38-1)-893 NSF CHE-75-13752 77/00/00 6 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: The use of functionalized polymers as photosensitizers  
in an energy storage reaction

AUTH: A/HAUTALA, R. R.; B/LITTLE, J.; C/SWEET, E. PAA:  
C/(Georgia, University, Athens, Ga.)  
Solar Energy, vol. 19, no. 5, 1977, p. 503-508.

MAJS: /\*ACCELERATING AGENTS/\*ENERGY STORAGE/\*ISOMERIZATION/\*  
PHOTOCHEMICAL REACTIONS/\*PHOTOSENSITIVITY/\*SOLAR  
ENERGY CONVERSION

MINS: / KETONES/ SOLAR COLLECTORS/ SOLAR SPECTRA/ SOLVENTS  
ABA: (Author)

ABS: Insoluble polymer-bound photosensitizers, useful for  
the conversion of norbornadiene (1) to quadricyclene  
(2), have been synthesized. An acetophenone analog was  
produced by Friedel-Crafts acylation of polystyrene  
resin, while treatment of chloromethylated resin with  
salicylaldehyde and triethylamine produced an analog of  
benzyloxybenzaldehyde. Reaction of lithio-polystyrene  
resin with methyl 4-(N,N-dimethylamino)benzoate gave a  
ketone equivalent to 4-(N,N-dimethylamino)benzophenone  
(3). Quantum yields for the conversion of 1 and 2  
using the polymer-bound sensitizers were generally  
comparable to, but slightly lower than, the analogous  
compound in homogeneous solution. The quantum yield of  
polymer-bound 3 was less solvent dependent than that  
of the homogeneous counterpart. The advantages of  
isolating the photosensitizer to the photochemical  
reactor stage of a photochemical solar energy storage  
device are discussed. Efficient sensitization by  
polymer-bound photosensitizers demonstrates the  
feasibility of this approach.

TJ New options in energy technology ... cl977.  
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I. American Institute of Aeronautics  
and Astronautics, II, Edison Electric  
Institute, III, Institute of Electrical  
and Electronics Engineers, Power Engi-  
neering Society

Storage Batteries: The Case and the Candidates - J. R. BIRK... p.12.....

Compressed Air Energy Storage - K. G. VOSBURGH..... p.17.....

Thermal Storage for Electric Utilities - C. J. SWET and W. J. MASICA. p.26

78A42136 ISSUE 18 PAGE 3295 CATEGORY 44  
77/00/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: Photochemical conversion and storage of solar energy  
/An overview/

AUTH: A/SAMANTA, U.; B/TARAFDAR, R.; C/ROHATGI-MUKHERJEE,  
K. K. PAA: C/(Jadavpur University, Calcutta, India)  
In: National Solar Energy Convention, Calcutta, India,  
November 29-December 1, 1976, Proceedings. (A78-42101  
18-44) Calcutta, Jadavpur University, 1977, p.  
135-138.

MAJS: /\*ENERGY STORAGE/\*PHOTOCHEMICAL REACTIONS/\*  
PHOTOVOLTAIC CONVERSION/\*SOLAR ENERGY CONVERSION

MINS: / COPPER CHLORIDES/ ELECTROCHEMICAL CELLS/ ENERGY  
TECHNOLOGY/ PHOTOELECTRIC MATERIALS/ PHOTOSYNTHESIS/  
PHOTOVOLTAIC CELLS/ SEMICONDUCTING FILMS/ THERMAL  
ENERGY

ABA: D.M.W.

ABS: It is noted that an important natural mechanism for  
the storage of solar energy is green plant  
photosynthesis. Three approaches involving the use of  
photochemical reactions in deliberate engineering  
schemes to store solar energy are discussed. In the  
first, photochemical endergonic reactions store energy  
in stable photoproducts, e.g., Glauber's salt  
sensitized with CuCl, which release heat energy later  
on, as needed. The second involves  
photoelectrochemical devices, e.g., Fe-thionine  
cells, which generate electrode-active species under  
illumination, and undergo a reverse reaction in the  
dark, generating an electrical current. Finally, a  
method is presented whereby a photosynthetic membrane  
having the properties of a semiconductor is used to  
separate photooxidized and photoreduced forms, which  
can then couple as required through a recycling of  
electrons through an external circuit.

ENERGY: TRANSMISSION, STORAGE, AND MANAGEMENT.

I. Fells.

Chemistry in Britain, v13, no.6, June 1977,  
p.222-226.

The storage of energy has not previously presented  
any real problems, although its transmission and  
management have.

**A Simulation Model for Wind Energy Storage Systems.  
Volume 2: Operation Manual.**

A. W. Warren, R. W. Edsinger, and J. D. Burroughs.  
Boeing Computer Services, Inc., Seattle, Wash. Energy  
Technology Applications Div. Aug 77, 421p NASA-CR-  
135284, BCS-40180-2-V-2

**N78-20803/OWE** Price code: PC A18/MF A01

A comprehensive computer program (SIMWEST) developed for the modeling of wind energy/storage systems utilizing any combination of five types of storage (pumped hydro, battery, thermal, flywheel, and pneumatic) is described. Features of the program include: a precompiler which generates computer models (in FORTRAN) of complex wind source/storage/application systems, from user specifications using the respective library components; a program which provides the techno-economic system analysis with the respective I/O the integration of system dynamics, and the iteration for conveyance of variables; and capability to evaluate economic feasibility as well as general performance of wind energy systems. The SIMWEST operation manual is presented and the usage of the SIMWEST program and the design of the library components are described. A number of example simulations intended to familiarize the user with the program's operation is given along with a listing of each SIMWEST library subroutine.

Solar Energy, v.19, 1977, p.669-75.

**USE OF TRANSITION METAL COMPOUNDS  
TO SENSITIZE A PHOTOCHEMICAL ENERGY  
STORAGE REACTION**

CHARLES KUTAL, DWIGHT P. SCHWENDIMAN and PAUL GRUTSCH  
Department of Chemistry, University of Georgia, Athens, GA 30602, U.S.A.

(Received 20 October 1976; in revised form 9 December 1976)

**Abstract**—A solar energy storage system based upon the valence isomerization of norbornadiene to quadricyclene possesses several attractive features, including high specific energy storage capacity, kinetic stability of the energy rich photo-product in the absence of suitable catalysts, and relatively inexpensive reactants. An inherent difficulty with the system is the lack of absorption of solar energy by norbornadiene. Attempts to overcome this shortcoming have focused upon the use of transition metal compounds to sensitize the desired energy storage step. Results to date indicate that complexation of norbornadiene to the metal provides a potentially useful route to sensitization. Several copper(I) compounds have thus far been found to be effective. The factors which affect the ability of a transition metal compound to function as a sensitizer via a complexation mechanism are discussed.

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**Intersociety Energy Conversion Engineering  
Conference, 12th, Washington, 1977.**

**Proceedings of the 12th Intersociety  
Energy Conversion Engineering Conference.**

- 779188 — **Economics of Internal and External Energy Storage in Solar Power Plant Operation**, R. Manvi, T. Fujita, *Jet Propulsion Lab., Pasadena, Calif.* ..... 1167
- 779189 — **An Assessment of Mechanical Energy Storage for Solar Systems**, H. M. Dodd, Jr., R. E. D. Stewart, S. G. Varnado, *Sandia Lab., Albuquerque, N. Mex.*; E. A. Aronson, G. C. Chang, *ERDA, Washington, D.C.* ..... 1174
- 779190 — **Evaluation of a Chemical Heat Storage System for a Solar Steam Power Plant**, J. Dayan, S. Lynn, A. Foss, *University of California, Berkeley, Calif.* ..... 1181
- 779191 — **Thermal Energy Storage**, M. K. Wright, B. L. Pierce, F. R. Spurrer, *Westinghouse Electric Co., Pittsburgh, Pa.* ..... 1190
- 779192 — **Integration of High Temperature Thermal Energy Storage into a Solar Thermal Brayton Cycle Power Plant**, W. D. Beverly, W. W. Engle, F. O. Mahony, *Boeing Eng. & Const., Seattle, Wash.* ..... 1195

TJ  
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Energy development III / sponsored by the IEEE Energy Development Subcommittee of the IEEE Power Generation Committee of the IEEE Power Engineering Society. — New York : Institute of Electrical and Electronics Engineers, c1977.

170 p. : ill. ; 28 cm. — (IEEE Power Engineering Society Papers ; 3)

**The Potential for Application of Energy Storage Capacity on Electric Utility Systems in the United States - Part II,**  
by V. T. Sulzberger and J. Zemkoski.....p.151.....

**A Simulation Model for Wind Energy Storage Systems.**  
**Volume 1: Technical Report.**  
 A. W. Warren, R. W. Edsinger, and Y. K. Chan.  
 Boeing Computer Services, Inc., Seattle, Wash. Energy  
 Technology Applications Div. Aug 77. 101p NASA-CR-  
 135283, BCS-40180-1-V-1  
**N78-20802/2WE** Price code: PC A06/MF A01

A comprehensive computer program for the modeling of wind energy and storage systems utilizing any combination of five types of storage (pumped hydro, battery, thermal, flywheel and pneumatic) was developed. The level of detail of Simulation Model for Wind Energy Storage (SIMWEST) is consistent with a role of evaluating the economic feasibility as well as the general performance of wind energy systems. The software package consists of two basic programs and a library of system, environmental, and load components. The first program is a precompiler which generates computer models (in FORTRAN) of complex wind source storage application systems, from user specifications using the respective library components. The second program provides the techno-economic system analysis with the respective I/O, the integration of systems dynamics, and the iteration for conveyance of variables. SIMWEST program, as described, runs on the UNIVAC 1100 series computers.

(SAND-76-9058) Energy storage needs for wind power systems. Reed, J.W. (Sandia Labs., Albuquerque, N.Mex. (USA)). 1977. Contract EY-76-C-04-0789. 20p. (CONF-770210-6). Dep. NTIS, PC A02/MF A01.

From A.A. advancement of science conference; Denver, Colorado, United States of America (USA) (20 Feb 1977).

Wind varies on all time scales, but hourly and longer term oscillations are most important to economical wind energy extraction schemes. Periodic variations in available wind energy, of diurnal, synoptic, annual, and larger scales, are not often correlated with demand so that some form of energy storage is needed. Most current ERDA-sponsored research in wind energy assumes connection to an existing power network and resource storage in the form of saved fossil fuels. Long term hourly wind observations at several representative U.S. locations have been used to show that a totally independent and perfectly reliable wind energy system would require an impractically large storage capacity, primarily to cover year-to-year and annual cycles of available wind energy. As reliability is allowed to decrease, a considerable reduction in storage capacity is possible. This is demonstrated by statistical results for several climatic regimes.

TJ Dumon, R.  
 910 **Energie solaire et stockage d'energie /**  
 .D76 **R. Dumon. — Paris : Masson, c1977.**  
 vi, 134 p. : ill. ; 25 cm.  
 Bibliography: p. 127-129.

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TK **Intersociety Energy Conversion Engineering**  
 2896 **Conference, 12th, Washington, 1977.**  
 .I55 **Proceedings of the 12th Intersociety**  
 1977 **Energy Conversion Engineering Conference,**

V. I 779083 — The Design of a Sodium Sulfate Decahydrate Heat Exchanger for Coolness Storage, F. A. Costello, S. Kumar, Intertechnology Corp., Warren, Va. ....	511
779086 — Conversion and Storage of Wind Energy as Nitrogenous Fertilizer, M. B. Dubey, Lockheed, Burbank, Calif. ....	525
779087 — ERDA's Chemical Energy Storage Program, J. H. Swisher, ERDA, Washington, D.C.; I. H. Kelley, Jet Propulsion Lab., Pasadena, Calif. ....	533



32922 Prospects for the photochemical storage of solar energy. Bolton, J.R. (Univ. of Western Ontario, London). pp 11p, Paper 55 of Solar energy update '77: Canada. Edmonton, Alberta; Univ. of Alberta (1977).

From 3. conference of the Solar Energy Society of Canada; Edmonton, Alberta, Canada (22 Aug 1977).

The possibilities for the photochemical storage of solar energy are examined from the standpoint of maximum efficiency. Loss factors are considered for a general endergonic photochemical reaction and it is concluded that a realistic maximum solar energy storage efficiency for any photochemical system is 15 to 16%. The natural process of photochemical storage, namely photosynthesis, is analyzed and it is found that the maximum storage efficiency of photosynthesis is 9.5%. Kinetic and thermodynamic limitations on a photochemical energy storage process are identified and it is shown that the desirable production of hydrogen and oxygen from water probably cannot be sensitized with visible light if only one photochemical step is employed. However, by analogy with the mechanism of photosynthesis, two photochemical reactions operating in series can permit a full utilization of the photochemically active part of the solar spectrum. A possible scheme is described and analyzed as to its possibilities and potential difficulties. Finally some of the systems being studied, where hydrogen gas is produced photochemically are described.

CN-150,920 1977  
EXPERIMENTAL INVESTIGATION OF THE OPERATING  
CHARACTERISTIC OF A PLASMA FOCUS. (Experiment-  
telle Untersuchung der Betriebscharakteristik  
eines Plasmafokus). H. Rapp. (Translation  
of rept. dtd Jan.1974). 1977. 117p.

Los Alamos Scientific Lab., LA-TR-77-69  
N. Mex.  
Stuttgart Univ., Inst. fuer IPF-74-1  
Plasmaforschung (W.Ger.)

Plasma focus  
Plasma acceleration  
Pinch effect  
Energy storage

CAN E-D-00

# Energy storage

1976

TA Critical materials problems in energy pro-  
403 duction / edited by Charles Stein. --  
.C74 New York : Academic Press, 1976.  
xii, 915 p. : ill. ; 25 cm.

"This volume is the result of a series of distinguished lectures sponsored by the Joint Center for Materials Science in New Mexico."

- |            |   |     |
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| Chapter 22 | Materials Problems in Rechargeable Batteries                    |     |
|            | ELTON J. CAIRNS   | 685 |
| Chapter 23 | Solid Solution Electrodes                                       |     |
|            | B.C.H. STEELE   | 711 |
| Chapter 24 | Solid Electrolytes  |     |
|            | ROBERT A. HUGGINS   | 729 |
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| Chapter 28 | Metal Hydrides for Energy Storage                               |     |
|            | G. G. LIBOWITZ  | 825 |



TJ 153 .E4733 pt.2  
 Energy development II ... c1976. (Card 2)  
 covering papers presented at the National  
 Power Engineering Society meetings."  
 1. Power resources--Congresses. 2.  
 Electric power--Congresses. I. IEEE.  
 Power Engineering Society. IEEE Power  
 Generation Committee. Energy Development

The Potential for Application of Energy Storage Capacity on Electric Utility  
 Systems in the United States--Part I, by V. T. Sulzberger and J. Zemkoski

Assessment of Storage Systems: The Device Utility Interface,  
 by T. R. Schneider and R. V. Snow.....

TJ 810 .I465 1976  
 International Conference on the Photochemical  
 Conversion and Storage of Solar Energy, 1st,  
 University of Western Ontario, 1976.  
 Solar power and fuels : proceedings of  
 the First International Conference on the  
 Photochemical Conversion and Storage of  
 Solar Energy, London, Canada, August 24-28,  
 1976 / edited by James R. Bolton ; sponsored  
 by the Photochemistry Unit, University of  
 Western Ontario and the Department of Chem-

77V17608 1976 ISS: 00 TJ165.N37 1976 0-309025-30-3 621  
 : 333.7 LC-76-47080 C 77-019578C.2: S 77-019560C.1:  
 771134

UTTL: Criteria for energy storage R & D : TLSP: a report /  
 by the Committee on Advanced Energy Storage Systems.  
 Energy Engineering Board, Assembly of Engineering,  
 National Research Council.  
 National Research Council. Committee on Advanced  
 Energy Storage Systems.  
 National Academy of Sciences. Washington : vii, 103 p.  
 illus.

77V22543 1976 ISS: 10 TJ153.E5  
 UTTL: Energy storage: user needs and technology  
 applications: a conference sponsored by the  
 Engineering Foundation under the joint chairmanship of  
 Electric Power Research Institute and Energy Research  
 and Development Administration.  
 Engineering Foundation, New York. Electric Power  
 Research Institute. U.S. Energy Research and  
 Development Administration.  
 ERDA Technical Information Center, Oak Ridge, Tenn.,  
 52 p.  
 On cover: Executive summary.  
 LC: Energy storage--Congresses.  
 NASA: / CONFERENCES/ ENERGY STORAGE/ ENERGY TECHNOLOGY  
 / TECHNOLOGY TRANSFER  
 MAIN-TITL TRACE-CORP: CATLG BY-JOHNSON  
 77/03/07 AVAIL: / JOHNSON

77N24612# ISSUE 15 PAGE 2013 CATEGORY 44 RPT#:  
 ANL-ES-50 CNT# W-31-109-ENG-38 76/05/00 30 PAGES  
 UNCLASSIFIED DOCUMENT

UTTL: Electric storage heating: The experience in England  
 and Wales and in the Federal Republic of Germany  
 AUTH: A/ASBURY, J. G.; B/KOUVALIS, A.  
 CORP: Argonne National Lab., Ill. AVAIL:NTIS SAP: HC  
 A03/MF A01  
 MAJS: /ELECTRIC POWER PLANTS/\*ENERGY STORAGE/\*ENGLAND/\*  
 GERMANY/\*HEATING  
 MINS: / FEASIBILITY/ SYSTEMS ENGINEERING/ UNITED STATES OF  
 AMERICA  
 ABA: ERA  
 ABS: The policies, methods, and circumstances under which  
 electric storage heating was commercialized in Europe  
 are reviewed, and background information for  
 evaluating the feasibility of commercial applications  
 in the United States is given.

TJ 810 .W68 1975  
 Workshop on Solar Energy Storage Subsystems  
 for the Heating and Cooling of Buildings,  
 Charlottesville, Va., 1975.  
 Proceedings of the Workshop on Solar  
 Energy Storage Subsystems for the Heating  
 and Cooling of Buildings, Charlottesville,  
 Virginia, April 16-18, 1975 / sponsored by  
 the National Science Foundation, Research  
 Applied to National Needs, and Energy Re-  
 search and Development Administration,

Z Wind energy bibliography. Mukwonago,  
 5853 Wisconsin, Windworks, 1974.  
 .P83 1 v. (unpaged) 23 cm.  
 W53 Cover title.  
 RR 1. Power resources--Bibliography.  
 2. Wind power--Bibliography. I.  
 Windworks (Firm)

6 STORAGE

Batteries  
 Compressed Air  
 Flywheels  
 General

Energy storage : developing advanced technologies.  
 Robinson, A. L. In : Energy : Use Conservation  
 and Supply, Abelson, P. H. (ed.). Washington,  
 D. C., American Assoc. for the Advancement of  
 Science, 1974, pp.148-150.

This paper presents a brief review of the  
 different ideas which have been proposed as  
 viable means to store energy. These ideas  
 include superconducting magnetic storage plants,  
 flywheels, hydrogen conversion and thermal  
 storage. Other methods which are only just  
 emerging are mentioned, and these include  
 steam storage, and coal gasifiers from which  
 gas can be stored at high pressure. ( F.C.S.).

TJ Storage, water heater, data communication,  
 810 education : joint conference, American  
 .S48 Section, International Solar Energy So-  
 1976 ciety and Solar Energy Society of Canada,  
 v.8 inc., August 15-20, 1976, Winnipeg / editor  
 K. W. Boer. -- Cape Canaveral, Fla. : Ameri-  
 can Section of the International Solar  
 Energy Society, c1976.  
 x, 371 p. : ill. ; 28 cm. -- (Sharing

PHOTOCHEMICAL STORAGE OF SOLAR ENERGY

## ENERGY STORAGE - BATTERIES

B0N14504# ISSUE 5 PAGE 619 CATEGORY 44 RPT#:  
 AD-A074869 UDR-TR-79-35 UDSE-TR-79-02  
 AFESC/ESL-TR-79-20 CNT#: F33615-77-C-2004 79/07/00  
 148 PAGES UNCLASSIFIED DOCUMENT  
 UTTL: Analysis of remote site energy storage and generation  
 systems --- systems analysis of solar energy  
 conversion and windpower utilization energy storage  
 systems TLSP: Final Technical Report, Jul. 1978 -  
 Jun. 1979  
 AUTH: A/CRISP, J. N.; B/BISHOP, W. S.; C/PINSON, J. D.;  
 D/ANDERSON, L. A.  
 CORP: Dayton Univ., Ohio. CSS: (School of Engineering.)  
 AVAIL.NTIS SAP: HC A07/MF A01  
 MAJS: /\*ENERGY STORAGE/\*SOLAR ENERGY CONVERSION/\*SYSTEMS  
 ANALYSIS/\*WINDPOWER UTILIZATION  
 MINS: / HYDROGEN/ OXYGEN/ STORAGE BATTERIES/ SYSTEMS  
 ENGINEERING/ TURBOGENERATORS  
 ABA: GRA  
 ABS: This report presents the results of an investigation  
 and analysis of energy storage systems and alternate  
 energy sources for remote site applications. The first  
 phase of the effort centered on the broad based study  
 of hydrogen storage, thermal storage, batteries, and  
 flywheels as energy storage systems along with wind  
 turbine, solar photovoltaic, and solar thermionic  
 energy converters. A wind turbine battery system was  
 recommended based on performance, cost and  
 availability. Effort under the second phase of the  
 program concentrated on a system using two separate  
 nominal eight kilowatt wind turbine modules in  
 conjunction with a lead-acid battery energy storage  
 unit. The system was specified to operate in  
 conjunction with an existing power grid system located  
 at Bar Main, Barter Island, Alaska. Specific system  
 concepts and recommendations are presented with  
 supporting analyses. A design checklist is included  
 with specific items for consideration in the  
 preparation of a design specification.

B0N13685# ISSUE 4 PAGE 504 CATEGORY 44 RPT#:  
 ANL-79-1 CNT#: W-31-109-ENG-38 79/03/00 35 PAGES  
 UNCLASSIFIED DOCUMENT  
 UTTL: Engineering development of lithium/metal sulfide  
 battery technology for vehicle propulsion TLSP:  
 Summary Report, Oct. 1977 - Sep. 1978  
 AUTH: A/BARNEY, D. L.; B/CHILENSKAS, A. A.; C/DELUCA, W.  
 H.; D/HAYES, E. R.; E/HORNSTRA, F.; F/FARAHAT, M.  
 K.; G/GRAAE, J. A. E.; H/BOX, S.  
 CORP: Argonne National Lab., Ill. AVAIL.NTIS SAP: HC  
 A03/MF A01  
 MAJS: /\*ELECTRIC AUTOMOBILES/\*ELECTRIC BATTERIES/\*LITHIUM  
 COMPOUNDS/\*SULFIDES  
 MINS: / BATTERY CHARGERS/ ELECTRICAL PROPERTIES/  
 ELECTROCHEMISTRY/ PERFORMANCE TESTS  
 ABA: DOE  
 ABS: The research, development, and management activities  
 done in preparation for in vehicle testing of  
 engineering scale lithium/metal sulfide batteries are  
 described. The equipment needed to evaluate the  
 performance of this battery is described. Testing of  
 this equipment is discussed. A portable  
 charger/equalizer that has the capability of charging  
 up to six lithium/metal sulfide cells is examined.

TIME VARIATION OF PRESSURE AND OXYGEN ABSORPTION  
 CURRENT IN SEALED ALKALINE STORAGE BATTERIES. V. M.  
 Mokhnatkin, E. A. Khomskaya.

Soviet Electrochemistry, vol 15, no 9, September 1979,  
 p. 1178-1179



79A51809# ISSUE 23 PAGE 4375 CATEGORY 44

79/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Commercial phosphoric acid fuel cell system technology development

AUTH: A/PROKOPIUS, P. R.; B/WARSHAY, M.; C/SIMONS, S. N.; D/KING, R. B. PAA: D/(NASA, Lewis Research Center, Fuel Cell Projects Office, Cleveland, Ohio)

CORP: National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979. Proceedings, Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 538-543.

MAJS: /\*ENERGY STORAGE/\*FUEL CELLS/\*PHOSPHORIC ACID/\* TECHNOLOGY ASSESSMENT

MINS: / COOLING SYSTEMS/ ELECTRIC POWER PLANTS/ ENERGY

TECHNOLOGY/ FABRICATION/ SYSTEMS ENGINEERING

ABA: (Author)

ABS: A review of the current commercial phosphoric acid fuel cell system technology development efforts is presented. In both the electric utility and on-site integrated energy system applications, reducing cost and increasing reliability are the technology drivers at this time. The longstanding barrier to the attainment of these goals, which manifests itself in a number of ways, has been materials. The differences in approach among the three major participants (United Technologies Corporation (UTC), Westinghouse Electric Corporation/Energy Research Corporation (ERC), and Engelhard Industries) and their unique technological features, including electrodes, matrices, intercell cooling, bipolar/separator plates, electrolyte management, fuel selection and system design philosophy are discussed.

BON70564# CATEGORY 44 RPT#: SAND-79-1127C

CONF-790595 CNT#: EY-76-C-04-0789 79/05/16 11 PAGES UNCLASSIFIED DOCUMENT

UTTL: Batteries for specific solar applications

AUTH: A/CLARK, R. P.

CORP: Sandia Labs., Albuquerque, N. Mex. AVAIL:NTIS

Presented at the DOE Semi-annual Review for Photovoltaics Technol. Development and Applications, Gatlinburg, Tenn., 16 May 1979

MAJS: /\*ELECTRIC BATTERIES/\*PHOTOVOLTAIC CELLS/\*SOLAR ENERGY

MINS: / ENERGY STORAGE/ ENERGY TECHNOLOGY/ STORAGE BATTERIES

79A27207 ISSUE 10 PAGE 1834 CATEGORY 44

79/03/00 7 PAGES UNCLASSIFIED DOCUMENT

UTTL: Superbatteries - A progress report --- for utility energy storage and electric vehicles

AUTH: A/BIRK, J. R.; B/KLUNDER, K.; C/SMITH, J. C. PAA: A/(Electric Power Research Institute, Palo Alto, Calif.); C/(U.S. Department of Energy, Washington, D.C.)

IEEE Spectrum, vol. 16, Mar. 1979, p. 49-55.

MAJS: /\*ELECTRIC MOTOR VEHICLES/\*ENERGY STORAGE/\*SODIUM SULFUR BATTERIES/\*STORAGE BATTERIES

MINS: / ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY/ LEAD ACID BATTERIES/ LITHIUM SULFUR BATTERIES/ ZINC CHLORIDES

ABA: A.A.

ABS: Future batteries, known as superbatteries, expected to be used as replacements for scarce fuel sources in the utilities and transportation sectors, are discussed. The sodium-sulfur model is considered as an example, noting that while the lead-acid battery, as almost all conventional batteries, contains solid electrodes and a liquid electrolyte, the sodium-sulfur contains liquid electrodes and a solid electrolyte, which makes for longer life. Progress in designing inexpensive and well performing lead-acid batteries is taken into account, emphasizing the development of seals using bonding by thermal compression, and of high-quality beta-alumina electrolyte tubes. The performance of electric vehicles is noted, together with a description of the various requirements facing the battery designer, including cruise speed, acceleration, and engine life. Cost problems impeding the full-scale development and commercialization of superbatteries are mentioned

BON15608# ISSUE 6 PAGE 764 CATEGORY 44 RPT#: SAND-79-0487 CNT#: EY-76-C-04-0789 79/06/00 16 PAGES UNCLASSIFIED DOCUMENT

UTTL: Long-term lithium battery tests

AUTH: A/LEVY, S. C.

CORP: Sandia Labs., Albuquerque, N. Mex. AVAIL:NTIS

SAP: HC A02/MF A01

MAJS: /\*ENERGY STORAGE/\*LITHIUM/\*PERFORMANCE TESTS/\*STORAGE BATTERIES

MINS: / ELECTRIC DISCHARGES/ LIFE (DURABILITY)/ OPERATING TEMPERATURE/ TEMPERATURE EFFECTS

ABA: A.W.H.

ABS: A six year program for testing ambient temperature in lithium batteries is discussed. Lithium sulfur dioxide cells and lithium polycarbon monofluoride cells are included in the tests. The test plan includes capacity versus rate, storage, and simulated operation. Data, taken six months into the test, is presented for storage at room temperature and capacity versus rate data is plotted for the cells.



79A31367 ISSUE 12 PAGE 2224 CATEGORY 44 RPT#:  
SAE PAPER 790162 79/02/00 10 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: A high energy tubular battery for a 1800 kg payload  
electric delivery van

AUTH: A/WHITEHEAD, M. L. PAA: A/(Chloride Technical, Ltd.,  
England)  
Society of Automotive Engineers, Congress and  
Exposition, Detroit, Mich., Feb. 26-Mar. 2, 1979. 10  
p.

MAJS: /\*ELECTRIC MOTOR VEHICLES/\*LEAD ACID BATTERIES/\*TRUCKS/  
/\*TUBE CATHODES

MINS: / BATTERY CHARGERS/ ENERGY TECHNOLOGY/ HIGH VOLTAGES/  
PROPULSIVE EFFICIENCY/ SERVICE LIFE \*

ABA: (Author)

ABS: A high energy lead-acid battery was developed to  
provide, at no extra cost, a 1800 kg (4000 lb) payload  
electric delivery van with a driving range of 80 - 90  
km (50 to 55 miles). In addition to the new high  
performance electrodes, an integrated approach to the  
total power source concept evolved new lightweight  
designs for battery packaging, a system-engineered  
battery charger, and an automatic topping-up facility.  
Despite the 40% improvement in range, as compared to  
55 - 65 km (35 - 40 miles) for conventional traction  
batteries, a 4 year battery life is expected due to  
the reinforcing features of the tubular design adopted  
for the positive electrode.

80N14530# ISSUE 5 PAGE 622 CATEGORY 44 RPT#:  
CONF-790538-10 CNT#: W-31-109-ENG-38 79/00/00 15  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Lithium/metal sulfide battery development

AUTH: A/STEUNENBERG, R. K.

CORP: Argonne National Lab., Ill. AVAIL NTIS SAP: HC  
A02/MF A01

Presented at Fast Ion Transport in Solids-Electrode  
and Electrolytes Conf., Lake Geneva, Wis., 21 May 1979

MAJS: /\*ENERGY STORAGE/\*LITHIUM SULFUR BATTERIES/\*STORAGE  
BATTERIES

MINS: / CELL ANODES/ CELL CATHODES/ ELECTRIC MOTOR VEHICLES/

ELECTRIC POWER SUPPLIES/ ENERGY TECHNOLOGY/ MOLTEN  
SALT ELECTROLYTES

ABA: DOE

ABS: Lithium/metal sulfide batteries developed for electric  
vehicle propulsion and for stationary energy storage  
applications such as load leveling are described. The  
battery cells consist of lithium-aluminum or  
lithium-silicon negative electrodes, iron sulfide (FeS  
or FeS<sub>2</sub>) positive electrodes, and molten LiCl-KCl  
electrolyte. The cells are enclosed in a thermally  
insulated jacket to maintain an operating temperature  
of 400 to 500 C. A 40 kwh electric vehicle battery  
consisting of 120 Li-Al/FeS cells is described.

80N10664# ISSUE 1 PAGE 92 CATEGORY 44 RPT#:  
UCRL-B2710 CONF-790803-17 CNT#: W-7405-ENG-48  
79/05/14 7 PAGES UNCLASSIFIED DOCUMENT

UTTL: Effect of mechanical energy storage systems on the  
characteristics of electric vehicles

AUTH: A/SCHWARTZ, M. W.

CORP: California Univ., Livermore, Lawrence Livermore Lab.  
AVAIL NTIS SAP: HC A02/MF A01

Presented at the 14th Intersoc. Energy Conversion  
Conf., Boston, 5-10 Aug. 1979; Sponsored by the Am.  
Chem. Soc.

MAJS: /\*ELECTRIC BATTERIES/\*ELECTRIC MOTOR VEHICLES/\*ENERGY  
CONVERSION/\*ENERGY STORAGE

MINS: / DISTANCE/ POWER EFFICIENCY/ PROPULSION SYSTEM  
PERFORMANCE

ABA: DOE

ABS: Batteries for electric vehicle propulsion were  
investigated to see if effective trade-offs between  
short term peak power capability and energy storage  
capacity are possible. It was found that batteries in  
combination with a mechanical energy storage device  
can optimize both power and range capability of an  
electric vehicle. Equations were derived for  
determining the vehicle mass fraction of the  
mechanical energy storage system that is required to  
achieve a vehicle mass saving or increase in range.  
The extent to which mechanical energy storage systems  
can improve electric vehicle performance was found to  
depend upon the battery type and the vehicle  
power/mass requirements.

N80-15608# Sandia Labs., Albuquerque, N. Mex.

#### LONG-TERM LITHIUM BATTERY TESTS

S. C. Levy Jun. 1979 16 p. ref

(Contract EY-76-C-04-0789)

(SAND-79-0487) Avail. NTIS HC A02/MF A01

A six year program for testing ambient temperature in lithium  
batteries is discussed. Lithium sulfur dioxide cells and lithium  
polycarbon monofluoride cells are included in the tests. The test  
plan includes capacity versus rate, storage, and simulated  
operation. Data, taken six months into the test, is presented for  
storage at room temperature and capacity versus rate data is  
plotted for the cells. AWH

79A46666 ISSUE 20 PAGE 3791 CATEGORY 44  
79/08/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Heat transfer in lead-acid batteries designed for electric-vehicle propulsion application  
AUTH: A/CHOI, K. W.; B/YAO, N. P. PAA: B/(Argonne National Laboratory, Argonne, Ill.)  
(American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers, Thermophysics and Heat Transfer Conference, 2nd, Palo Alto, Calif., May 24-26, 1978.) Electrochemical Society, Journal, vol. 126, Aug. 1979, p. 1321-1328. Research supported by the U.S. Department of Energy.  
MAJS: /\*ELECTRIC MOTOR VEHICLES/\*HEAT TRANSFER/\*LEAD ACID BATTERIES  
MINS: / ELECTRIC AUTOMOBILES/ ELECTRIC CHARGE/ GRAPHS (CHARTS)/ TEMPERATURE DISTRIBUTION  
ABA: (Author)  
ABS: Mathematical analysis has been carried out for the heat transfer in lead-acid batteries designed for use in electric vehicles. This analysis has shown that the heat generated in the battery during recharge cycles may cause a noticeable rise of battery temperature in the absence of proper thermal management. The results have shown that the ratio of the temperature rise during charge is closely related to the ratio of the energy densities of the two batteries. Of the cooling methods examined, electrolyte circulation along the battery plates was found to be the most effective in removing heat and providing a uniform temperature field. Numerical solutions are provided for the engineering evaluation of heat-removal design during battery cycling processes.

79A31363 ISSUE 12 PAGE 2224 CATEGORY 44 RPT#:  
SAE PAPER 790158 CNT# ERDA 31-109-38-3628 ERDA  
31-109-38-4206 79/02/00 11 PAGES UNCLASSIFIED DOCUMENT

UTTL: Electric vehicle battery development  
AUTH: A/FLEISCHMANN, C. W. PAA: A/(Eltra Corp., Electric Vehicle Group, Plymouth Meeting, Pa.)  
Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 26-Mar. 2, 1979. 11 p.  
ABA: G.R.  
ABS: A description is presented of the development of a new lead-acid battery for electric vehicle propulsion applications. The battery which is being developed uses expanded metal, nonantimonial alloy grids, enveloped separation/retention, and high-rate production methods of packaging including through-the-wall construction. The battery is expected to meet the Department of Energy goals for the improved state-of-the-art electric vehicle battery and to be further improved to meet the Department of Energy goals for the advanced battery.

79A51832 ISSUE 23 PAGE 4377 CATEGORY 44  
79/00/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: A zinc-bromine battery for energy storage  
AUTH: A/PUTT, R. A. PAA: A/(Gould, Inc. Energy Research Laboratory, Rolling Meadows, Ill.)  
In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979. Proceedings, Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 683-690.  
MAJS: /\*BROMINE/\*ELECTRIC BATTERIES/\*ELECTROCHEMICAL CELLS/\* ENERGY STORAGE/\*STORAGE BATTERIES/\*ZINC  
MINS: / COSTS/ ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY/ PERFORMANCE TESTS  
ABA: (Author)  
ABS: The battery comprises a cell stack of titanium electrodes and a DARANIC microporous separator, a bromine storage device apart from the cell stack, and a plumbing network which circulates the electrolyte between the two. Testing of laboratory cells and batteries has shown this system to be capable of a high efficiency, a long cycle life, and the inherent reliability required for the utility application. Based on the results of a cost and design study, a large (100 MWh) utility battery would comprise an array of self contained, truckable, 400 kWh modules, the cost of which, although high for the first design, is subject to considerable reduction via modifications.

N80-15611# Argonne National Lab., Ill. Chemical Engineering Div.

#### LITHIUM/IRON SULFIDE BATTERIES FOR ELECTRIC VEHICLES

P. A. Nelson, A. A. Chilenskas, and R. K. Steunenberg 1978  
24 p refs. Presented at the 5th Intern. Electric Vehicle Symp., Philadelphia, 2-5 Oct. 1978  
(Contract W-31-109-eng-38)  
(CONF-781006-2) Avail: NTIS HC A02/MF A01

Recent progress in the development of LiAl/FeS/sub x/ batteries for electric vehicles is assessed. The possibility of near-term commercialization of a version of the battery that utilizes monosulfide (FeS) positive electrodes in conjunction with low cost, iron alloy current collectors is indicated. Multiple-electrode cells having a specific energy of about 100 Wh/kg are now under test. Conceptual design problems for a compact insulating jacket, which will maintain the battery temperature at 450 C, appear to be solved. Work is also underway on a version of the battery that would utilize FeS2 positive electrodes, which use molybdenum current collectors at present and may require the future development of less expensive current collectors to be commercially attractive. These batteries would ultimately have about 30 to 40% higher specific energy and 50 to 75% higher specific power than the FeS-type batteries. DOE

79A10092 ISSUE 1 PAGE 110 CATEGORY 44 CNT#:  
EY-76-C-03-1169 78/00/00 6 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Advances in lower cost phosphoric acid fuel cells  
AUTH: A/JOHNSON, W. H.; B/COYKENDALL, R. D.; C/HANDLEY, L.  
M.; D/MARICLE, D. L.; E/MIENTEK, A. P. PAA:  
E/(United Technologies Corp., Power Systems Div.,  
South Windsor, Conn.)

In: Intersociety Energy Conversion Engineering  
Conference, 13th, San Diego, Calif., August 20-25,  
1978. Proceedings, Volume 1. (A79-10001 01-44)  
Warrendale, Pa., Society of Automotive Engineers,  
Inc., 1978, p. 732-737.

MAJS: /\*COST REDUCTION/\*ELECTRIC POWER PLANTS/\*FUEL CELLS/\*  
PERFORMANCE TESTS/\*PHOSPHORIC ACID

MINS: / COOLING SYSTEMS/ ENERGY TECHNOLOGY/ PRESSURE EFFECTS  
/ PRESSURE VESSELS/ SERVICE LIFE/ TECHNOLOGY  
ASSESSMENT/ TEMPERATURE EFFECTS

ABA: B.U.

ABS: In 1976 the Department of Energy sponsored a  
phosphoric acid fuel cell technology program which  
made important contributions to the fuel cell power  
section and fuel processor technology of the 4.8-MW  
Demonstrator power plant scheduled to be operated in  
the Consolidated Edison utility network in 1979. This  
program was continued for 1977 and 1978 with the  
primary objective of identifying improvements in  
phosphoric acid cell technology and power plant design  
which, if developed, would permit construction of a  
power plant equivalent to the 4.8-MW Demonstrator but  
lower in both manufacturing and operating cost. In  
addition, an effort was recently undertaken to provide  
technology improvements of the new ribbed substrate  
cell concept for the 40-kW on-site power plant  
development program.

**N80-16286#** Brookhaven National Lab., Upton, N. Y.  
**PROCEEDINGS OF THE HYDRIDE STORAGE RESERVOIR  
SYMPOSIUM/WORKSHOP**  
M. J. Rosso, Jr. 1978 79 p refs Symp. held at Upton, N.Y.  
20 Jun. 1978

(Contract EY-76-C-02-0016)

(BNL-26523; CONF-7806165) Avail: NTIS HC A05/MF A01

Problems related to hydride reservoir internal engineering  
design and container materials, hydride bed heat and mass transfer,  
and the fundamental properties of hydrides, addressed at the  
workshop are listed. The abstracts of 12 papers delivered are  
presented. The texts of two papers not delivered are included.  
These discuss development of low cost nickel-rare earth hydrides  
for hydrogen storage and an exact solution of diffusion and  
absorption of hydrogen in uranium followed by fracture of the  
hydride  
DOE

79A10084\* ISSUE 1 PAGE 109 CATEGORY 44 CNT#:  
EC-77-A-31-1011 78/00/00 5 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Rapid, efficient charging of lead-acid and nickel-zinc  
traction cells --- for electric vehicles

AUTH: A/SMITHRICK, J. J. PAA: A/(NASA, Lewis Research  
Center, Cleveland, Ohio)

CORP: National Aeronautics and Space Administration, Lewis  
Research Center, Cleveland, Ohio.

In: Intersociety Energy Conversion Engineering  
Conference, 13th, San Diego, Calif., August 20-25,  
1978. Proceedings, Volume 1. (A79-10001 01-44)  
Warrendale, Pa., Society of Automotive Engineers,  
Inc., 1978, p. 672-676. NASA-supported research;

MAJS: /\*CHARGING/\*ELECTRIC MOTOR VEHICLES/\*ENERGY CONVERSION  
EFFICIENCY/\*LEAD ACID BATTERIES/\*NICKEL ZINC BATTERIES

MINS: / CAPACITY/ ELECTRIC PULSES/ ELECTROLYTIC CELLS/  
ENERGY TECHNOLOGY/ OUTGASSING/ TIME DEPENDENCE/  
TRACTION

ABA: B.U.

ABS: Lead-acid and nickel-zinc traction cells were rapidly  
and efficiently charged using a high rate tapered dc  
charge (HRTDC) method which could possibly be used for  
on-the-road service recharge of electric vehicles. The  
HRTDC method takes advantage of initial high cell  
charge acceptance and uses cell gassing rate and  
temperature as an indicator of charging efficiency. On  
the average, 300 amp-hour nickel-zinc traction cells  
were given a HRTDC to 78% of rated amp-hour capacity  
within 53 minutes at an amp-hour efficiency of 92% and  
an energy efficiency of 52%. Three-hundred amp-hour  
lead-acid traction cells were charged to 69% of rated  
amp-hour capacity within 46 minutes at an amp-hour  
efficiency of 91% with an energy efficiency of 64%.

79N28700\*# ISSUE 19 PAGE 2570 CATEGORY 44  
78/00/00 10 PAGES UNCLASSIFIED DOCUMENT

UTTL: Acceptance test data on Hughes-USAF lightweight nickel  
hydrogen cells

AUTH: A/ROGERS, H. H.

CORP: Hughes Aircraft Co., Los Angeles, Calif. AVAIL: NTIS

SAP: HC A23/MF A01

In NASA, Goddard Space Flight Center 11th Ann.  
Battery Workshop p 331-340 (SEE N79-28669 19-44)

MAJS: /\*ACCEPTABILITY/\*NICKEL HYDROGEN BATTERIES/\*  
PERFORMANCE TESTS

MINS: / CAPACITANCE/ CYCLES/ ELECTRIC CHARGE/ FAILURE  
ANALYSIS

ABA: R.E.S.

ABS: Cell capacity, stabilization cycling, and failure  
analysis data on 50 A hour lightweight nickel hydrogen  
cells is presented and discussed.



78A52895 ISSUE 24 PAGE 4384 CATEGORY 44  
78/00/00 10 PAGES UNCLASSIFIED DOCUMENT DCAF  
A324000

UTTL: Reliability simulation of a large solar battery  
AUTH: A/BOGOMOLNY, A.; B/GERTSBAKH, I.; C/SLONIM, M.  
PAA: C/(Negev, University, BeerSheva, Israel)  
In: Photovoltaic Solar Energy Conference, Luxembourg,  
September 27-30, 1977. Proceedings. (A78-52776 24-4)  
Dordrecht, D. Reidel Publishing Co., 1978, p.  
1201-1270.  
MAJS: /\*COMPUTERIZED SIMULATION/\*ELECTRIC BATTERIES/\*  
RELIABILITY ANALYSIS/\*SOLAR ARRAYS  
MINS: / ENERGY TECHNOLOGY/ FAILURE/ SOLAR CELLS/ VOLT-AMPERE  
CHARACTERISTICS

ABA: B.U.

ABS: The paper examines the reliability behavior of a large solar battery consisting of several thousand solar cells. The output power was chosen as the reliability index reflecting changes in the battery when many individual cells fail. More precisely, the reliability index is the expected (mean) output power at a given operation time or the expected operation time at which the output power will decrease a given amount. The main goal of the reliability simulation was to obtain a 'bundle' of sample curves representing the random decrease of output power.

79A17315 ISSUE 5 PAGE 841 CATEGORY 44 78/00/00  
5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Energy storage requirements for autonomous and hybrid solar thermal electric power plants  
AUTH: A/IANNUCCI, J. J.; B/SMITH, R. D.; C/SWET, C. J.  
PAA: A/(Sandia Laboratories, Livermore, Calif.);  
B/(Rocket Research Co., Redmond, Wash.); C/(U.S.  
Department of Energy, Washington, D.C.)  
In: Sun: Mankind's future source of energy.  
Proceedings of the International Solar Energy  
Congress, New Delhi, India, January 16-21, 1978.  
Volume 1. (A79-17276 05-44) Elmsford, N.Y., Pergamon  
Press, Inc., 1978, p. 482-486. Research supported by  
the U.S. Department of Energy.

ABA: B.U.

ABS: The cost of electricity from an autonomous solar thermal electric conversion (STEC) plant which uses the (SO3/SO2/O2) reaction for seasonal storage is compared to that of a solar plant with alternate energy backup (i.e., a hybrid solar plant). The cost of this alternate energy (provided by an on-site combustion turbine or purchased from a utility whenever necessary) is balanced against the economics of the STEC plant to determine the optimum (i.e., minimum busbar energy cost) solar/backup mix of the hybrid plant as well as the storage requirements of that mix. Over a range of alternate energy costs and geographic locations, the hybrid system was found to be economically superior to the autonomous STEC plant.

79A17969 ISSUE 5 PAGE 665 CATEGORY 44 78/00/00  
393 PAGES UNCLASSIFIED DOCUMENT

UTTL: Progress in batteries and solar cells. Volume 1 ---  
Book

AUTH: A/KOZAWA, A.; B/KORDESCH, K. V.; C/VOSS, E.;  
D/CADANO, J. P.; E/FUEKI, K.; F/JOSEPH, H. M.;  
G/IKEDA, H.; H/SHIROGAMI, T. PAA: C/(Varta Batterie  
AG, Kelkheim, West Germany); D/(Societe des  
Accumulateurs Fixes et de Traction, Romainville,  
Seine-Saint-Denis, France); E/(Tokyo, University,  
Tokyo, Japan); F/(Union Carbide Corp., Battery  
Products Div., New York, N.Y.); G/(Sanyo Electric  
Co., Japan); H/(Tokyo Shibaura Electric Co., Ltd.,  
Toshiba Research and Development Center, Kawasaki,  
Japan); B/(Graz, Technische Universitaet, Graz,  
Austria) PAT: A/(E.D.) SAP: \$36  
Cleveland, Ohio, JEC Press, Inc., 1978, 393 p (For  
individual items see A79-17990 to A79-17997)

MAJS: /\*ELECTRIC BATTERIES/\*SOLAR CELLS  
MINS: / ABSTRACTS/ ALKALINE BATTERIES/ ELECTRIC MOTOR  
VEHICLES/ ELECTROLYTES/ LEAD ACID BATTERIES/ LITHIUM/  
MANGANESE OXIDES/ MARKET RESEARCH/ NICKEL CADMIUM  
BATTERIES/ NICKEL ZINC BATTERIES/ PATENTS/  
PHOTOELECTRIC CELLS/ PHOTOELECTROCHEMICAL DEVICES/  
PRIMARY BATTERIES/ PRODUCT DEVELOPMENT/ RESEARCH AND  
DEVELOPMENT/ SOLAR ENERGY CONVERSION/ STORAGE  
BATTERIES/ TECHNOLOGY ASSESSMENT

ABA: M.L.

ABS: Research on batteries, information on new devices, and sales data are presented. Topics discussed include primary batteries, lead-acid batteries, electric vehicles and batteries, alkaline rechargeable batteries, solid state batteries, fuel cells, Na-S batteries, batteries for energy storage, photochemical cells, solar cells, and an MnO2 project. Patents, events of 1977, new test methods, and production figures are considered.

78V36281 1978 ISS: 00 TK2901.RB 0-805924-55-8 621.3509  
LC-78-103078

AUTH: A/Ruben, Samuel.  
UTTL: The evolution of electric batteries in response to industrial needs / by Samuel Ruben.  
Dorrance, Philadelphia : xii, 97 p. : 33 ill. : 22 cm.  
\$7.95

LC: Electric batteries -- History.  
MAIN-AUTH TRACE-TITL: CATLG BY-LC  
/ /



A79-21676 Hydrides for energy storage; Proceedings of the International Symposium, Geilo, Norway, August 14-19, 1977. Symposium sponsored by the Institutt for Atomenergi and Allied Chemical Corp. Edited by A. F. Andersen (Institutt for Atomenergi, Kjeller, Norway) and A. J. Maeland (Allied Chemical Corp., Morristown, N.J.). Oxford, Pergamon Press, Ltd., 1978. 611 p. \$60. (For individual items see A79-21677 to A79-21717)

Consideration is given to the prospects of hydrogen as an energy carrier for the future, structure and bonding in metal hydrides, the nature of He-3 confinement in transition metal hydrides, hydrogen adsorption in rare earth intermetallic compounds, and the use of FeTi-hydrides for production and storage of suprapure hydrogen. Papers are also presented on such topics as hysteresis effects in metal-hydrogen systems, electrochemical utilization of metal hydrides, hydrogen storage electrode systems, the hydrogen/hydride energy concept, and the metallurgy and production of rechargeable hydrides. B.J.

79N73814# CATEGORY 44 RPT#: ANL-78-21 CNT#: W-31-109-ENG-38 78/03/00 89 PAGES UNCLASSIFIED DOCUMENT

UTTL: High-performance batteries for stationary energy storage and electric-vehicle propulsion TLSP: Progress Report, Oct. - Dec. 1977

CORP: Argonne National Lab., Ill. AVAIL:NTIS

MAJS: /\*ELECTRIC MOTOR VEHICLES/\*ENERGY STORAGE/\*PRODUCTION ENGINEERING/\*STORAGE BATTERIES

MINS: / ALUMINUM ALLOYS/ ELECTROLYTES/ LITHIUM SULFUR BATTERIES/ TECHNOLOGY TRANSFER

QD 181 .H1 H92 Hydrides for energy storage : proceedings of an international symposium held at Geilo, Norway, 14-19 August 1977 / edited by A. F. Andresen and A. J. Maeland : organized by the Netherlands-Norwegian Reactor School, Institutt for Atomenergi, Kjeller, Norway. — Oxford ; New York : Pergamon Press, 1978.

xvi, 599 p. : ill.

ISBN 0-09-022715-5

1. Hydrides— Congresses.  
2. Energy Stor— ace—Congresses.

79429488 ISSUE 11 PAGE 2057 CATEGORY 44 77/00/00 3 PAGES UNCLASSIFIED DOCUMENT

UTTL: Prospects for improvements in lead-acid batteries --- for electric vehicles

AUTH: A/ACTON, R. G.; B/SUTCLIFFE, P. PAA: B/(Oldham and Son, Ltd., Denton, Manchester, England) In: International Conference on Electric Vehicle Development, London, England, May 31, June 1, 1977.

Proceedings. (A79-29487 11-85) Hitchin, Herts., England, Peter Peregrinus, Ltd., 1977, p. 3-5.

MAJS: /\*ELECTRIC ENERGY STORAGE/\*ELECTRIC MOTOR VEHICLES/\*LEAD ACID BATTERIES/\*TECHNOLOGICAL FORECASTING/\*TRANSPORTATION ENERGY

MINS: / ELECTROLYTIC POLARIZATION/ ENERGY TECHNOLOGY/ MAINTENANCE/ TEMPERATURE CONTROL/ WEIGHT REDUCTION

ABA: A.L.W.

ABS: The prospects for improving lead acid batteries for electric vehicles in the areas of energy density, recharging time and maintenance are assessed. It is found that battery weight reduction can be achieved by replacing positive grid plates with tubular components, using plastic or lighter metal grids for negative plates and by using 'through the wall' techniques for intercell connectors. An increase in energy density to 45 Wh/kg for a five hour discharge is foreseen. Automatic and semi-automatic watering systems have been developed to reduce the amount of maintenance. Methods proposed to enable rapid charging (in less than an hour) without excessive temperature rise include a system of high speed pulse discharging during the charging process to prevent electrode polarization and a new battery design based on foil technology.

78V13530 1977 ISS: 11 T0153.E5

JTTL: Energy storage: TLSP: user needs and technology applications, a conference sponsored by the Engineering Foundation under the joint chairmanship of Electric Power Research Institute and Energy Research and Development Administration, Engineering Foundation, New York, Electric Power Research Institute, U. S. Energy Research and Development Administration, Conference on Energy Storage, Asilomar, Pacific Grove, Calif., 1976. ERDA Technical Information Center, Oak Ridge, Tenn., 424 p. illus.

U. S. Energy Research and Development Administration, CONF-760212

LC: Energy Storage--Congresses.

NASA: / CONFERENCES/ ELECTRIC POWER SUPPLIES/ ENERGY STORAGE/ TECHNOLOGY ASSESSMENT

MAIN-MEET TRACE-SERS-CORP CATLG BY-JOHNSON 77/12/21 AVAIL: / JOHNSON

78A16923\*# ISSUE 4 PAGE 630 CATEGORY 44  
 77/04/00 15 PAGES UNCLASSIFIED DOCUMENT  
 UTTL: New batteries and their impact on electric vehicles  
 AUTH: A/SCHWARZ, H. J. PAA: A/(NASA, Lewis Research  
 Center, Cleveland, Ohio)  
 CORP: National Aeronautics and Space Administration, Lewis  
 Research Center, Cleveland, Ohio.  
 Electric Vehicle Council, International Electric  
 Vehicle Exposition and Conference, 1st, Chicago, Ill.,  
 Apr. 26-29, 1977. Paper, 15 p.  
 MAJS: /\*ELECTRIC AUTOMOBILES/\*ELECTRIC BATTERIES/\*STORAGE  
 BATTERIES/\*TRANSPORTATION ENERGY  
 MINS: / ENERGY TECHNOLOGY/ NICKEL ZINC BATTERIES/ RESEARCH  
 AND DEVELOPMENT/ TECHNOLOGICAL FORECASTING  
 ABA: M.L.  
 ABS: The paper is concerned with the development of  
 the electric vehicles and electric vehicle batteries. The  
 present and predicted performance levels of some  
 battery systems such as lead-acid, nickel-iron,  
 nickel-zinc, and zinc-chlorine are considered, as are  
 the characteristics that an electric vehicle must  
 possess in order to appeal to customers. The  
 implications of battery improvements for manufacturers  
 of electric vehicles are discussed. Lack of knowledge  
 of passenger range requirements for electric vehicles  
 is noted.

77A44564 ISSUE 21 PAGE 3613 CATEGORY 44 RPT#:  
 SAE PAPER 770281 77/02/00 10 PAGES UNCLASSIFIED  
 DOCUMENT  
 UTTL: A new design for the high-performance sodium-sulfur  
 battery  
 AUTH: A/HATTORI, S.; B/YAMAMURA, M.; C/KIMURA, S.;  
 D/IKABUCHI, S. PAA: D/(Yusasa Battery Co., Ltd.,  
 Takatsuki, Osaka, Japan)  
 Society of Automotive Engineers, International  
 Automotive Engineering Congress and Exposition,  
 Detroit, Mich., Feb. 28-Mar. 4, 1977. 10 p. Research  
 sponsored by the Ministry of International Trade and  
 Industry of Japan.  
 MAJS: /\*ELECTRIC BATTERIES/\*ELECTROLYTIC CELLS/\*SODIUM/\*  
 SULFUR  
 MINS: / ENERGY TECHNOLOGY/ NONAQUEOUS ELECTROLYTES/  
 PERFORMANCE TESTS/ SOLID ELECTRODES  
 ABA: (Author)  
 ABS: This paper describes a new design for the  
 sodium-sulfur battery employing a new cell  
 construction including a new method to join the solid  
 electrolyte tube with the sodium reservoir made of  
 metal, and an improved composition of the cell case to  
 solve the problems of premature cell destruction and  
 capacity decrease associated with our conventional  
 design. As a result a higher and more stable  
 performance of the new design than that of our  
 conventional design has been shown through various  
 evaluation tests.

79N14565# ISSUE 5 PAGE 622 CATEGORY 44 RPT#:  
 MTR-7593 CNT#: EC-77-C-01-5025 77/11/00 268 PAGES  
 UNCLASSIFIED DOCUMENT  
 UTTL: Lead-acid battery: An evaluation of commercialization  
 strategies  
 AUTH: A/DAVIS, F.; B/KUCHNEL, R.; C/PRICE, J.; D/SMITH,  
 G.  
 CORP: Milne Corp., McLean, Va. AVAIL NTIS SAE: HC  
 A12/MF A01  
 MAJS: /\*ELECTRIC POWER PLANTS/\*ENERGY STORAGE/\*LEAD ACID  
 BATTERIES/\*MARKET RESEARCH  
 MINS: / COST EFFECTIVENESS/ LITERATURE/ MARKETING/ STORAGE  
 BATTERIES  
 ABA: DOE  
 ABS: The lead-acid battery energy storage for electric  
 utility peaking applications in the near term is  
 explored. A review of existing literature and  
 interviews with selected electric utilities are used  
 to identify key parameters for market acceptance.  
 Analytical techniques are developed to quantify these  
 parameters and estimates of regional and national  
 market size are made. Possible government actions are  
 identified and qualitative criteria and measurements  
 of cost effectiveness are developed.

79A11837 ISSUE 2 PAGE 267 CATEGORY 44 77/00/00  
 13 PAGES UNCLASSIFIED DOCUMENT  
 UTTL: Batteries for transportation and load-leveling  
 applications  
 AUTH: A/LANDGREBE, A. R. PAA: A/(U.S. Department of  
 Energy, Washington, D.C.)  
 In: Symposium on Electrode Materials and Processes for  
 Energy Conversion and Storage, Philadelphia, Pa., May  
 9-12, 1977. Proceedings. (A79-11776 02-25) Princeton,  
 N.J., Electrochemical Society, Inc., 1977, p. 937-949.  
 MAJS: /\*ELECTRIC MOTOR VEHICLES/\*ENERGY STORAGE/\*STORAGE  
 BATTERIES  
 MINS: / AIR/ ELECTRIC AUTOMOBILES/ ELECTRIC POWER PLANTS/  
 ENERGY TECHNOLOGY/ LEAD ACID BATTERIES/ LITHIUM/  
 NICKEL ZINC BATTERIES/ UTILITIES  
 ABA: M.L.  
 ABS: Secondary storage battery systems under consideration  
 for automotive propulsion applications are examined.  
 Performance requirements are described, and lead acid,  
 nickel-iron, nickel-zinc, zinc-chlorine, iron-air,  
 lithium-metal sulfide, and sodium-sulfur batteries are  
 discussed. It is suggested that the last two systems  
 are good candidates for electric vehicles. The effect  
 of battery characteristics on electric car design is  
 considered.

78N18551# ISSUE 9 PAGE 1181 CATEGORY 44  
77/12/00 18 PAGES UNCLASSIFIED DOCUMENT

UTTL: Electric car technology for demonstration and development

AUTH: A/HAMILTON, W.

CORP: General Research Corp., Santa Barbara, Calif.  
AVAIL NTIS SAP: HC A24/MF A01  
In Union Coll. Effects of Energy Constraints on Transportation Systems p 439-456 (SEE N78-18529 09-44)

MAJS: /\*ELECTRIC BATTERIES/\*ELECTRIC MOTOR VEHICLES/\*ENERGY POLICY/\*PROJECT PLANNING

MINS: / AUTOMOBILES/ ELECTRIC POWER SUPPLIES/ ENERGY CONSERVATION/ INTERNAL COMBUSTION ENGINES

ABA: Author

ABS: The performance characteristics of the electric cars which were developed around the world were characterized. It was reported that the acceleration capability of the electric cars is sluggish in comparison with the conventional ICE engines. Comprehensive data on the elements of operating cost as a function of the service characteristics were provided. It concluded that the future potential of electric automobiles depends mainly upon battery development. Batteries have always imposed critical technical limitations on the range and speed of electric cars. There has been relatively little progress in propulsion batteries compared with improvements in ICE auto technology. The battery improvements are a prerequisite towards the introduction of electric cars in the urban arena. Life cycle cost per kilometer versus range were documented for several types of electric cars and compared with the conventional ICE car. Changes in fuel prices could reduce or eliminate the cost disadvantages of the electric cars.

78N79682# CATEGORY 44 RPT#: AD-A054322  
REPT-0035-4-VOL-2 CNT#: DAAK02-75-C-0035 77/11/00  
140 PAGES UNCLASSIFIED DOCUMENT

UTTL: Production and engineering methods for carb-tek (trade name) batteries in fork lift trucks volume 2: Standard operating procedures TLSP: Final Report, Nov. 1976 - Nov. 1977

AUTH: A/SCHAEFER, J. C.

CORP: Electric Storage Battery Co., Yardley, Pa. CSS: (ESB Technology Center.) AVAIL NTIS

MAJS: /\*ELECTRIC BATTERIES/\*FORKS/\*PRODUCTION ENGINEERING

MINS: / ELECTROLYTES/ GRAPHITE/ SEALS (STOPPERS)/ SODIUM CHLORIDES/ TELLURIUM COMPOUNDS

V 78N29604# ISSUE 20 PAGE 2692 CATEGORY 44 RPT#: TID-27914 PR-10 CNT#: EY-76-C-02-2949 77/11/00 20 PAGES UNCLASSIFIED DOCUMENT

UTTL: Development of an iron-air battery system for electric vehicles TLSP: Progress Report, Jun. - Oct. 1977

AUTH: A/BUZZELLI, E. S.

CORP: Westinghouse Electric Corp., Pittsburgh, Pa. CSS: (Research and Development Center.) AVAIL NTIS SAP: HC A02/MF A01

MAJS: /\*AIR/\*ELECTRIC BATTERIES/\*IRON

MINS: / ELECTRODES/ VOLT-AMPERE CHARACTERISTICS

ABA: ERA

ABS: The development program on secondary iron-air cells continued to advance both electrodes, as well as establish state-of-the-art characteristics for 100 sq cm cells. Investigations on the air electrodes studied alternate electrode compositions fabricated by either the dry powder method or the wet pasting technique. Work on the iron electrode concluded some of the studies which were in progress. Initiated some exploratory work dealing with metal additives to the electrode, at a reduced level of effort. A new 25 foot hydrogen belt furnace was installed and made operational for iron electrode fabrication and studies. Increased effort was put into the building and testing of iron-air cells. These tests are initially intended to demonstrate the cycle stability of both the electrodes to establish a base line for future comparisons in a variety of configurations, without immediate concern for an optimized design. Results to date showed cyclic stability of the capacity of the iron electrode in 100 sq cm cells, while other cells showed stable voltage characteristics of the air electrode.

79N21581# ISSUE 12 PAGE 1593 CATEGORY 44  
77/09/00 15 PAGES UNCLASSIFIED DOCUMENT

UTTL: Charge and discharge profile

AUTH: A/MCDERMOTT, P. P.

CORP: Coppin State Coll., Baltimore, Md. AVAIL NTIS  
SAP: HC A25/MF A01  
In NASA. Goddard Space Flight Center The 1977 Goddard Space Flight Center Battery Workshop p 181-195 (SEE N79-21565 12-44)

MAJS: /\*ELECTRIC BATTERIES/\*ELECTRIC CHARGE/\*ELECTRIC DISCHARGES/\*ELECTROCHEMICAL CELLS/\*FAILURE ANALYSIS/\*SERVICE LIFE

MINS: / CURVE FITTING/ ELECTRIC CURRENT/ ELECTRIC POTENTIAL/ GRAPHS (CHARTS)/ HYSTERESIS/ REGRESSION ANALYSIS/ STORAGE BATTERIES

ABA: G.Y.

ABS: Some possible parameters which could be used to predict failures within packs of electrochemical cells based on measurements that are taken while the cells are cycling are discussed. Discharge and charge curves are presented and fitted to measure the efficiency of the cells in terms of voltage vs. time.



77A33429# ISSUE 14 PAGE 2377 CATEGORY 44  
77/09/00 4 PAGES In RUSSIAN UNCLASSIFIED DOCUMENT

UTTL: Method for determining the operational values of the electrical parameters of solar batteries  
AUTH: A/BORDINA, N. M.; R/KOVALSKII, V. IA. PAA:  
B/(Vnesoluznyi Nauchno-Issledovatel'skii Institut Istochnikov Toka, Moscow, USSR)  
Gellotekhnika, no. 1, 1977, p. 24-27. In Russian.  
MAJS: /\*ELECTRIC BATTERIES/\*ERROR ANALYSIS/\*PERFORMANCE PREDICTION/\*SOLAR CELLS/\*SOLAR SIMULATORS/\*VOLT-AMPERE CHARACTERISTICS  
MINS: / COMPUTER TECHNIQUES/ OPTIMIZATION/ PHOTOELECTRIC CELLS/ STATISTICAL ANALYSIS  
ABA: B.J.  
ABS: An analytic-experimental method based on the use of statistical simulation is used to determine the

operational values of the electrical parameters of solar batteries. The method, by proper selection of the radiation intensity of the solar simulator, allows the suppression of the error associated with the failure of the spectral and angular characteristics of the simulator to correspond to those of the sun

77N25675# ISSUE 16 PAGE 2156 CATEGORY 44 RPT#:  
AD-A035942 ECOM-4457 77/01/00 32 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Methanol-air batteries  
AUTH: A/PERRY, J. JR.  
CORP: Army Electronics Labs., Fort Monmouth, N. J.  
AVAIL NTIS SAP: HC A03/MF A01  
MAJS: /\*ELECTRIC BATTERIES/\*FUEL CELLS/\*METHYL ALCOHOLS  
MINS: / EFFICIENCY/ ELECTRODES/ ELECTROLYTES/ POTASSIUM HYDROXIDES/ SERVICE LIFE/ TEMPERATURE  
ABA: GRA  
ABS: The methanol-air battery shows promise of meeting the operational requirements of low power equipment, such as sensors, mines, and similar equipments. While primarily designed to satisfy low level output requirements, the system is capable of supporting transient peak loads on a cyclical basis. Cells charged with 120 ml of anolyte, consisting of 6 M methanol in 11 M KOH, have operated for 2,230 hours under cyclic load drains of 50 mA for 13 minutes and 2 A for 1 second. One cell operated for more than 8,000 hours with periodic refilling of fresh anolyte, demonstrating the long serviceable life of the electrode components. Fuel utilization efficiencies as high as 84 % have been obtained from cells charged with an anolyte solution of methanol in potassium hydroxide. Single cells charged with a fuel mixture of methanol and methyl formate in 5 M KOH operated satisfactorily under load at temperatures down to -40 C, with only a 30% decrease in voltage during the 2 A period of the cycle.

78N31548# ISSUE 22 PAGE 2961 CATEGORY 44 RPT#:  
ANL-K-77-3624-1 CNT#: W-31-109-ENG-38 77/09/00  
126 PAGES UNCLASSIFIED DOCUMENT

UTTL: Design and cost study for development of lead-acid batteries suitable for electric vehicle propulsion  
TLSP: Final Report  
AUTH: A/WEINLEIN, C. E.  
CORP: Globe-Union, Inc., Milwaukee, Wis. AVAIL NTIS  
SAP: HC A07/MF A01  
MAJS: /\*COST ANALYSIS/\*DESIGN ANALYSIS/\*ENERGY POLICY/\*LEAD ACID BATTERIES/\*TECHNOLOGY ASSESSMENT  
MINS: / ELECTRIC MOTOR VEHICLES/ ENERGY CONSERVATION/ ENERGY CONSUMPTION/ PERFORMANCE TESTS/ PROJECT MANAGEMENT  
ABA: Author (ERA)  
ABS: A design for an improved state-of-the-art (ISOA) battery is proposed. It is believed that this ISOA design is the most efficient design achievable within the constraints of the ISOA battery development program. These constraints include realistic time and financial limitations, and compatibility with existing highspeed production equipment. The ISOA battery is in fact an improved, state-of-the-art lead acid battery for use in an electric vehicle. A durable, light weight polypropylene container and cover complete with single point watering and venting features are incorporated in the ISOA design. A number of materials and process parameters with profound effect on battery performance were chosen after extensive evaluation and cell testing. Development of an advanced lead acid electric vehicle battery involved the evaluation and application of effective forward concepts in the design of the battery. Many weight-saving designs were incorporated. Significant improvements in active material efficiencies and integrity are required.

78N13607# ISSUE 4 PAGE 505 CATEGORY 44 RPT#:  
ANL-K-77-3558-1 REPT-762-003-1 CNT#: W-31-109-ENG-38  
77/02/15 127 PAGES UNCLASSIFIED DOCUMENT

UTTL: Develop nickel-zinc battery suitable for electronic vehicle propulsion. Task A: Design and cost study  
CORP: Gould, Inc., Rolling Meadows, Ill. CSS: (Nickel-Zinc Battery Project.) AVAIL NTIS SAP: HC A07/MF A01  
ABA: ERA  
ABS: A three-month design and cost study for the use of nickel-zinc batteries in electric vehicles is presented. Battery configuration is analyzed, and expected performance is set forth. Current development problems concern component materials and capacity decline on cycling, electrolyte maintenance, and thermal characteristics. The manufacturing process is outlined, and estimates are made for cost, materials requirements, and capital needs.



✓ 79N21585\*# ISSUE 12 PAGE 1593 CATEGORY 44  
77/00/00 20 PAGES UNCLASSIFIED DOCUMENT

UTTL: Storage effects on cells

AUTH: A/HARKNESS, J. M.

CORP: Naval Weapons Support Center, Crane, Ind.

AVAIL NTIS SAP: HC A25/MF A01

In NASA, Goddard Space Flight Center The 1977

Goddard Space Flight Center Battery Workshop p

223-242 (SEE N79-21565 12-44)

MAJS: /\*ELECTRIC BATTERIES/\*ELECTROCHEMICAL CELLS/\*SERVICE  
LIFE/\*STORAGE STABILITY

MINS: / ELECTRIC DISCHARGES/ ELECTRIC POTENTIAL/ GRAPHS  
(CHARTS)/ OAO/ SHORT CIRCUITS/ TABLES (DATA)

ABA: G.Y.

ABS: The results of an experiment to test storage effects  
on electric cells of a battery are presented and  
discussed. The type of cells were the 20 amp-hour OAO  
type. The various modes that were tested were the  
integration type mode, the trickle charge, the  
discharge shorted and the discharged OCV (open current  
voltage). Every six months the cells were  
reconditioned and approximately two weeks of tests  
were performed. The tests included three capacity  
checks, two zero-degree overcharge tests and an

internal short test (the cells are shunted for 16  
hours, the shunt removed and allowed to stand on local  
circuit recovery for 24 hours). The integration pack  
was discontinued after three years and the trickle  
charge shorted packs after five years.

79N11490# ISSUE 2 PAGE 201 CATEGORY 44 RPT#:  
COO-2857-1 77/10/21 101 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Battery Energy Storage Test (BEST) Facility.  
Phenomenological cell modeling: A tool for planning  
and analyzing battery testing at the BEST facility

AUTH: A/HYMAN, E. A.

CORP: Public Service Electric and Gas Co., Newark, N. J.;

Public Service Electric and Gas Research Corp.,

Maplewood, N. J. AVAIL NTIS SAP: HC A06/MF A01

Prepared in cooperation with Public Serv. Elec. and  
Gas Res. Corp., Maplewood, N. J.

ABA: DOE

ABS: Phenomenological cell modeling, a tool for battery  
testing is presented. The uses of modeling in the

battery cycling test program are described. The  
modeling and modeling needs are discussed in more  
general terms. Areas in which modeling would be useful  
are listed. Succeeding sections are critical. Surveys  
of available technical information in each area are  
included.

✓ 78N25593# ISSUE 16 PAGE 2142 CATEGORY 44 RPT#:  
ANL-77-68 CNTF: W-31-109-ENG-38 77/10/00 77 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: High-performance batteries for stationary energy  
storage and electric-vehicle propulsion TLSP:  
Progress Report, Apr. - Jun. 1977

CORP: Argonne National Lab., Ill. AVAIL NTIS SAP: HC  
A05/MF A01

ABS: Research, development, and management activities of  
the program on lithium aluminum/metal sulfide  
batteries are described. The cells are of a vertically  
oriented, prismatic design with a central positive  
electrode of FeS or FeS<sub>2</sub>, two facing negative  
electrodes of lithium - aluminum alloy, and a  
electrolyte of molten LiCl - KCl. The concepts  
receiving major attention are carbon-bonded positive  
electrodes, scaled-up designs of stationary energy  
storage cells, additives to extend electrode lifetime,  
alternative electrode separators, and pellet-grid  
electrodes. Materials development efforts included the  
development of a lightweight electrical feedthrough;  
studies of various current-collector designs;  
investigation of powder separators; wettability and  
corrosion tests of materials for cell components; and  
postoperative examinations of cells. Voltametric  
studies were conducted to investigate the  
reversibility of the FeS<sub>2</sub> electrode. The use of  
calcium and magnesium alloys for the negative  
electrode in advanced battery systems were  
investigated.

✓ 79N21604\*# ISSUE 12 PAGE 1595 CATEGORY 44  
77/00/00 12 PAGES UNCLASSIFIED DOCUMENT

UTTL: The 25 kN space station

AUTH: A/CLARK, B.

CORP: Grumman Aerospace Corp., Bethpage, N.Y. AVAIL NTIS

SAP: HC A25/MF A01

In NASA, Goddard Space Flight Center The 1977

Goddard Space Flight Center Battery Workshop p

463-474 (SEE N79-21565 12-44)

ABA: A.R.H.

ABS: The capabilities of photovoltaic, nuclear reactor, and  
solar thermal systems are assessed for the space  
construction base. Topics covered include Brayton  
conversion, thermionic conversion, and thermo-electric  
conversion. The effectiveness of nickel calcium and  
nickel hydrogen batteries are discussed as well as  
that of regenerative fuel cells. The verification of  
long cycle life for nickel hydrogen systems is  
recommended.

77A22894# ISSUE 8 PAGE 1255 CATEGORY 44  
76/08/00 27 PAGES UNCLASSIFIED DOCUMENT

UTTL: The nickel-zinc battery - A viable alternative for vehicle powering

AUTH: A/PIETROCELLI, A. W.; B/KENNEDY, J. H. PAA:  
B/(Yardney Electric Corp., Parcatuck, Conn.)  
Union Internationale des Producteurs et Distributeurs  
d'Energie Electrique and Electric Vehicle Council,  
International Electric Vehicle Symposium, 4th,  
Duesseldorf, West Germany, Aug. 31-Sept. 2, 1976,  
Paper, 27 p.

MAJS: /\*ELECTRIC MOTOR VEHICLES/\*ENERGY STORAGE/\*NICKEL ZINC  
BATTERIES/\*POWER EFFICIENCY

MINS: / AERODYNAMIC LOADS/ COMPUTER PROGRAMS/ ENERGY  
CONSUMPTION/ LEAD COMPOUNDS/ MARKET RESEARCH/  
MATHEMATICAL MODELS/ POLLUTION CONTROL/ POTENTIAL  
ENERGY/ PROPULSION SYSTEM PERFORMANCE/ URBAN  
TRANSPORTATION

ABA: S.D.

ABS: The paper reviews the analytical and hardware  
development work conducted at Yardney on the  
nickel-zinc battery system for structured on-road  
transportation. Realization of design targets for a  
nickel-zinc couple capable of increased energy density  
for range extension and of elevated power density for  
improved acceleration and gradeability is discussed. A  
simplified technical-economic analytical model is  
described whereby two types of special-purpose  
vehicles with lead-acid and nickel-zinc batteries are  
compared. For this purpose, a two-stage computer  
program operable on a small desk-top computer is  
designed to determine the resistive (drag) and  
inertial loads of the vehicle and to compare these in  
terms of consumed energy to available battery energy.  
Future potential of the nickel-zinc system and tasks  
to be accomplished for a late 1970s market  
introduction are noted.

78N77484# CATEGORY 44 RPT#: CONF-7606127-1 CNT#:  
W-31-109-ENG-38 76/00/00 15 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Federal battery program for transportation uses

AUTH: A/LANDGREBE, A. R.; B/KLUNDER, K.; C/YAO, N. P.  
CORP: Argonne National Lab., Ill. AVAIL NTIS

Presented at the 27th Power Sources Conf., Power  
Sources Tech. Area, Fort Monmouth, N. J., 21 Jun. 1976

MAJS: /\*ELECTRIC BATTERIES/\*RESEARCH PROJECTS/\*URBAN  
TRANSPORTATION

MINS: / ASSESSMENTS/ LITHIUM SULFUR BATTERIES/ METAL AIR  
BATTERIES/ NICKEL ZINC BATTERIES/ PREDICTIONS/  
ZINC-OXYGEN BATTERIES

77A28131 ISSUE 11 PAGE 1862 CATEGORY 44  
76/00/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Nickel battery systems for electric vehicles

AUTH: A/MILLER, L. E.; B/BROWN, R. A. PAA:  
B/(Eagle-Picher Industries, Inc., Joplin, Mo.)  
In: Power Sources Symposium, 27th, Atlantic City,  
N. J., June 21-24, 1976, Proceedings. (A77-28126 11-44)  
Red Bank, N. J., PSC Publications Committee, 1976, p.  
16-20.

MAJS: /\*COST REDUCTION/\*ELECTRIC MOTOR VEHICLES/\*ENERGY  
REQUIREMENTS/\*NICKEL HYDROGEN BATTERIES/\*NICKEL ZINC  
BATTERIES/\*STORAGE BATTERIES

MINS: / CAPACITY/ COMPUTERIZED SIMULATION/ COST  
EFFECTIVENESS/ ELECTROCHEMICAL CELLS/ PERFORMANCE/  
USER REQUIREMENTS

ABA: G.R.

ABS: A computer modeling study of vehicle applications and  
energy requirements indicated an intermediate energy  
density battery system could play a major role in  
electric vehicle development. The required battery  
system may very possibly be provided by a  
nickel-hydrogen system. The required energy densities  
are almost obtained in nickel-hydrogen systems for  
aerospace applications. However, a significant  
reduction in cost is required for an employment of the  
nickel-hydrogen system in electric vehicles.  
Possibilities for using nickel-iron and nickel-zinc  
battery systems for electric vehicles are also  
discussed.

✓ 77N17577# ISSUE 8 PAGE 1054 CATEGORY 44 RPT#:  
BNL-20990 76/01/26 13 PAGES UNCLASSIFIED DOCUMENT

UTTL: Comparing the electric lead-acid battery vehicle with  
a hydrogen fueled vehicle incorporating an Fe-Ti  
hydride storage unit

AUTH: A/WAIDE, C. H.

CORP: Brookhaven National Lab., Upton, N. Y. AVAIL NTIS  
SAP: HC A02/MF A01  
Sponsored by ERDA

MAJS: /\*ELECTRIC BATTERIES/\*PERFORMANCE TESTS/\*STORAGE  
BATTERIES

MINS: / AUTOMOBILES/ ELECTROMOTIVE FORCES/ ENERGY STORAGE/  
HYDROGEN FUELS

ABA: ERA

ABS: An electric vehicle powered by energy stored in  
lead-acid batteries is compared with a hydrogen fueled  
vehicle utilizing an internal combustion engine and  
iron-titanium hydride for the fuel storage. The  
comparison shows that for roughly equivalent vehicle  
types, the iron-titanium storage of hydrogen provides  
a vehicle with better range, better performance, and  
fewer operational limitations than an electric vehicle  
using lead-acid batteries.

✓ 77N27510# ISSUE 18 PAGE 2403 CATEGORY 44 RPT#:  
EPRI-EM-266 76/12/00 248 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Development of sodium-sulfur batteries for utility  
application TLSP: Annual Report

AUTH: A/CHATTERJI, D.

CORP: General Electric Co., Schenectady, N. Y. CSS: (Electrochemistry Branch.) AVAIL.NTIS SAP: HC  
A11/MF A01

Sponsored by EPRI

MAJS: /\*DESIGN ANALYSIS/\*ENERGY STORAGE/\*STORAGE BATTERIES

MINS: / COST ANALYSIS/ SODIUM/ STATISTICAL ANALYSIS/ SULFUR

ABA: ERA

ABS: The development of a sodium-sulfur battery system for  
bulk storage of energy is described. Two initial  
cell/module/system designs are discussed. The cell in  
these preliminary designs consists of many individual  
beta-alumina tubes used as the separator between  
single sodium and sulfur compartments. Heat conduction  
experiments were made and a complete thermal analysis  
of the system is given. A statistical analysis of the  
effects of failure or change in performance of  
individual cells or modules and a study on  
optimization of the system cost were performed.

✓ 77N19660# ISSUE 10 PAGE 1345 CATEGORY 44 RPT#:  
AD-A030627 SU-CMR-76-12 CNT#: N00014-75-C-1056 NR  
PROJ. 056-555 76/09/00 27 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Solid electrolyte battery materials TLSP: Final  
Report, period ending 30 Jun. 1976

AUTH: A/HUGGINS, R. A.

CORP: Stanford Univ., Calif. CSS: (Center for Materials  
Research.) AVAIL.NTIS SAP: HC A03/MF A01

MAJS: /\*ELECTRIC BATTERIES/\*ELECTROLYTES/\*RESEARCH AND  
DEVELOPMENT/\*SOLIDS

MINS: / ALUMINUM COMPOUNDS/ GRAPHITE/ LITHIUM COMPOUNDS/  
POLYMERS/ SILICATES/ TITANIUM COMPOUNDS

ABA: Author (GRA)

ABS: This is the Final Report on this contract. Work  
involved the preparation and property measurements on  
a number of potential ionic conductors and mixed  
ionic-electronic conductors, as well as the  
investigation of a novel technique for the preparation  
of oxide solid electrolytes. Especially interesting

were the results on several groups of new lithium  
ionic conductors.

\* 77N21550# ISSUE 12 PAGE 1607 CATEGORY 44  
RPT#: NASA-TM-X-71284 X-711-77-28 76/11/00 360  
PAGES UNCLASSIFIED DOCUMENT

UTTL: The 1976 Goddard Space Flight Center Battery Workshop  
CORP: National Aeronautics and Space Administration, Goddard  
Space Flight Center, Greenbelt, Md. AVAIL.NTIS

SAP: HC A16/MF A01

Workshop held at Greenbelt, Md., 9-10 Nov. 1976

MAJS: /\*ELECTRIC BATTERIES/\*ELECTROCHEMICAL CELLS/\*RESEARCH  
AND DEVELOPMENT

MINS: / NICKEL CADMIUM BATTERIES/ NICKEL HYDROGEN BATTERIES/  
PERFORMANCE TESTS

ABA: Author

ABS: The latest results of testing, analysis and  
development of sealed nickel cadmium cells and  
batteries and developments in the nickel-hydrogen  
system are discussed.

✓ 77N74766# CATEGORY 33 RPT#: NASA-CR-149755  
D180-18849-2-VOL-2 CNT#: NAS7-100 JPL-953984  
76/07/00 5 VOLS 355 PAGES UNCLASSIFIED DOCUMENT

UTTL: Battery literature search, bibliography and abstracts,  
volume 2

CORP: Boeing Co., Seattle, Wash.; Jet Propulsion Lab.,  
California Inst. of Tech., Pasadena. AVAIL.NTIS  
Prepared for JPL

MAJS: /\*ABSTRACTS/\*BIBLIOGRAPHIES/\*ELECTRIC BATTERIES

MINS: / AEROSPACE ENGINEERING/ ELECTROCHEMICAL CELL/  
ELECTROLYTIC CELLS

✓ 78N78365# CATEGORY 44 76/00/00 12 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Lead-acid batteries for utility application

AUTH: A/BIRK, J. R.

CORP: Electric Power Research Inst., Palo Alto, Calif.  
CSS: (Advanced Battery Systems.) AVAIL.NTIS  
In Battery Council Intern. Conv. - 1976 p 72-83 (SEE  
N78-78358 20-44)

MAJS: /\*ELECTRIC POWER SUPPLIES/\*LEAD ACID BATTERIES/\*  
STORAGE BATTERIES

MINS: / ELECTRIC BATTERIES/ TECHNOLOGY ASSESSMENT

78N13597# ISSUE 4 PAGE 504 CATEGORY 44 RPT#:  
EPRI-255-TR-2 ERDA-31-109-38-2062-TR-2 CNT#:  
W-31-109-ENG-38 75/08/00 160 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Conceptual design of a battery Energy Storage Test  
(BEST) facility

CORP: Bechtel Corp., San Francisco, Calif. AVAIL:NTIS  
SAP: HC AOB/MF A01

Sponsored in part by Elec. Power Res. Inst.

MAJS: /\*ENERGY STORAGE/\*STORAGE BATTERIES/\*TEST FACILITIES

MINS: / AUXILIARY POWER SOURCES/ COOLING SYSTEMS/ ECONOMIC  
FACTORS/ ENVIRONMENTAL ENGINEERING/ SAFETY FACTORS

ABA: J.M.S.

ABS: Design criteria for a battery energy storage test  
facility are presented. Systems to provide for  
functions such as battery cooling, building  
heating-ventilating-air-conditioning, station  
auxiliary power, and safety are described. Economic  
and environmental factors are included.

78N77460# CATEGORY 44 RPT#: ANL-8109 CNT#:  
W-31-109-ENG-38 75/01/00 136 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: High-performance batteries for off-peak energy storage  
and electric-vehicle propulsion TLSP: Progress  
Report, Jan. - Jun. 1974

CORP: Argonne National Lab., Ill. AVAIL:NTIS

MAJS: /\*ELECTRODES/\*ENERGY STORAGE/\*LITHIUM SULFUR BATTERIES

MINS: / CHEMICAL ANALYSIS/ ELECTROCHEMICAL CELLS/  
FABRICATION/ IRON COMPOUNDS/ LITHIUM ALUMINUM HYDRIDES



## ENERGY STORAGE - FUEL CELLS

✓ B0N14526# ISSUE 5 PAGE 621 CATEGORY 44 RPT#:  
 LA-UR-79-628 CONF-790803-16 CNT#: W-7405-ENG-36  
 79/00/00 11 PAGES UNCLASSIFIED DOCUMENT  
 UTTL: Applications of fuel cells in transportation  
 AUTH: A/MCCORMICK, B.; B/BOBBETT, R.; C/LYNN, D.;  
 D/NELSON, S.; E/SRINIVASAN, S.; F/MCCREEN, J. PAA  
 D/DOE, Washington, D.C.); E/(Brookhaven National  
 Lab.); F/(Brookhaven National Lab.)  
 CORP: Los Alamos Scientific Lab., N. Mex. AVAIL NTIS  
 SAP: HC A02/MF A01  
 Presented at the 14th Intersoc. Energy Conversion  
 Conf., Boston, 5-10 Aug. 1979  
 MAJS: /FUEL CELLS/MOTOR VEHICLES/TECHNOLOGY UTILIZATION/  
 URBAN TRANSPORTATION  
 MINS: /ECONOMIC ANALYSIS/FEASIBILITY ANALYSIS/PERFORMANCE  
 ABA: DOE  
 ABS: A detailed technical and economic evaluation of  
 potential applications for fuel cells in  
 transportation is given. Four vehicle types were  
 evaluated: city bus, highway bus, delivery van, and  
 consumer car, using fuel cell and reformer data.  
 Various fuel options and performance vs economic  
 tradeoffs were considered and final recommendations  
 are presented.

**N79-33594#** National Technical Information Service, Springfield,  
 Va.

### **FUEL CELLS, VOLUME 3. CITATIONS FROM THE NTIS DATA BASE Progress Report, 1977 - Jun. 1979**

Diane M. Cavagnaro Jul 1979 244 p Supersedes NTIS/PS-78/  
 0633. NTIS/PS-77/0544. NTIS/PS-76/0507. NTIS/PS-75/479.  
 and COM-74-11533  
 (NTIS/PS-79/0717/3. NTIS/PS-78/0633. NTIS/PS-77/0544.  
 NTIS/PS-76/0507. NTIS/PS-75/479. COM-74-11533) Avail.  
 NTIS HC \$28.00/MF \$28.00 CSCL 10B

Fuel cell applications, components, fabrication, design,  
 catalysts, and chemistry are covered. The bibliography includes  
 different types of fuel cells, such as hydrogen oxygen cells,  
 hydrocarbon air cells, and biochemical cells. This updated  
 bibliography contains 235 abstracts 97 of which are new entries  
 to the previous edition. GRA

✓ 79N21622# ISSUE 12 PAGE 1597 CATEGORY 44  
 RPT#: NASA-CR-160159 TPR-59 CNT#: NAS9-15286  
 79/03/22 73 PAGES UNCLASSIFIED DOCUMENT  
 UTTL: Solid Polymer Electrolyte (SPE) fuel cell technology  
 program TLSP: Final Report  
 CORP: General Electric Co., Wilmington, Mass. CSS: I  
 Aircraft Equipment Div.) AVAIL NTIS SAP: HC  
 A04/MF A01  
 MAJS: /ELECTRICAL PROPERTIES/ELECTROLYTES/FUEL CELLS/  
 TECHNOLOGY ASSESSMENT  
 MINS: /ELECTRODES/ENERGY STORAGE/LIFE (DURABILITY)/  
 PERFORMANCE/POLYMERS/RECOMMENDATIONS  
 ABA: G.Y.  
 ABS: The overall objectives of the Phase IV Solid Polymer  
 Electrolyte Fuel Cell Technology Program were to: (1)  
 establish fuel cell life and performance at  
 temperatures, pressures and current densities  
 significantly higher than those previously  
 demonstrated; (2) provide the ground work for a space  
 energy storage system based on the solid polymer  
 electrolyte technology (i.e., regenerative H<sub>2</sub>/O<sub>2</sub> fuel  
 cell); (3) design, fabricate and test evaluate a  
 full-scale single cell unit. During this phase,  
 significant progress was made toward the  
 accomplishment of these objectives.

**N79-33595#** National Technical Information Service, Springfield,  
 Va.

### **HYDROCARBON FUEL CELLS. CITATIONS FROM THE AMERICAN PETROLEUM INSTITUTE DATA BASE Report, 1967 - Apr. 1979**

Diane M. Cavagnaro Jul 1979 135 p Supersedes NTIS/PS-78/  
 0651  
 (NTIS/PS-79/0718/1; NTIS/PS-78/0651) Avail NTIS  
 HC \$28.00/MF \$28.00 CSCL 10B

This bibliography cites worldwide research on hydrocarbon  
 fuel cells. The citations cover applications, design, performance,  
 fabrication, catalysts, and electrochemistry. This updated  
 bibliography contains 128 abstracts, 3 of which are new entries  
 to the previous edition. GRA

TK	Intersociety Energy Conversion Engineering	
2896	Conference, 14th, Boston, 1979.	
.155	Proceedings of the 14th Intersociety	
1979	Energy Conversion Engineering Conference,	
	Boston, Massachusetts, August 5-10, 1979.	
	-- Washington, D. C. : American Chemical	
	Society, c1979.	
799109	Commercial Phosphoric Acid Fuel System	
	Technology Development, M. Warshay, P. Pro-	
	kopius, S. Simons and R.B. King .....	538
799110	The Role of Fuel Cells in NASA's Space Power	
	System, J. Been .....	544
799111	A 5-MW Acid Fuel Cell Power Plant Featuring	
	High Temperature Steam Reforming of No. 2	
	Fuel Combined with Autothermal Reforming,	
	K.K. Ushiba, I. Mahawili and T.H. Tio .....	550
799112	Scale-Up of Phosphoric Acid Fuel Cells,	
	L. Christner, H. Maru, C. Chi, S. Perkari and	
	M. Lambrech .....	554
799113	Tungsten Carbide/Platinum Fuel Cell System	
	with Phosphoric Acid as Electrolyte, R. Fleis-	
	chmann, H. Bohm and J. Heffler .....	559
799114	Molten Carbonate Fuel Cell Systems De-	
	velopment Program, S.S. Borys and J.P.	
	Ackerman .....	563
799115	Solid Electrolyte Fuel Cells for Electric Utility	
	Power Generation, S. Srinivasan and H.S.	
	Isaacs .....	568
799116	Molten Carbonate Fuel Cell Based, Coal Fired	
	Power Plants for Electric Power Generation,	
	T.L. Bonds, M.H. Dawes and A.W. Schnacke ..	578

799117	Fuel Cell Efficiency, T.G. Benjamin, E.H.	
	Camara, K.W. Hahn and J.R. Selman .....	579
799118	Molten Carbonate Fuel Cell Performance	
	Model for Cycle Studies, M.H. Dawes and L.W.	
	Spradlin .....	583
799119	Effect of Temperature and Pressure on Molten	
	Carbonate Fuel Cell Fuels and Performance,	
	K.W. Hahn, T.E. Tang and E.H. Camara .....	586

✓ 80A13223\* ISSUE 3 PAGE 419 CATEGORY 44  
 79/11/00 2 PAGES UNCLASSIFIED DOCUMENT  
 UTTL: Fuel cell sesquicentennial  
 AUTH: A/COHN, E. M. PAA: A/(NASA: U.S. Army, Army Research  
 Office, Washington, D.C.)  
 CORP: National Aeronautics and Space Administration,  
 Washington, D. C.; Army Research Office, Washington,  
 D. C.  
 Energy, vol. 4, Fall 1979, p. 13, 30.  
 MAJS: /\*ECONOMIC FACTORS/\*ENERGY TECHNOLOGY/\*FUEL CELLS/\*  
 TECHNOLOGICAL FORECASTING/\*TECHNOLOGY UTILIZATION  
 MINS: / RESEARCH AND DEVELOPMENT/ TECHNOLOGY ASSESSMENT  
 ABA: A.L.W.  
 ABS: The development of fuel cell technology is summarized,  
 and the potential for utility-type fuel cell  
 installations is assessed on the occasion of the 150th  
 anniversary of the construction of the first fuel cell  
 by Sir William Grove. The only functional fuel-cell  
 systems developed to date, the hydrogen-oxygen cells  
 used by NASA, are indicated, and hydrazine and alcohol  
 (methanol) cells are considered. Areas requiring  
 development before the implementation of fuel cells as  
 general purpose utility-type electric generators  
 include catalysts for naturally occurring hydrocarbons  
 or processes for low-cost methanol or hydrazine  
 production, efficient means of scrubbing and enriching  
 air, self-regulating systems, and 15- to 20-fold power  
 density increases. It is argued that although ideas  
 for eliminating certain of the above-mentioned  
 problems have been proposed, fuel-cell systems can  
 never be expected to equal the efficiency, reliability  
 and low cost of conventional power plants, and thus  
 developmental support should be discontinued.

79A40008 ISSUE 17 PAGE 3229 CATEGORY 44  
79/00/00 7 PAGES In GERMAN UNCLASSIFIED DOCUMENT

UTTL: A thermanalytical investigation of nickel catalysts for fuel cells

AUTH: A/GRUENE, H. PAA: A/(Siemens AG, Forschungslaboratorien, Erlangen, West Germany) Siemens Forschungs- und Entwicklungsberichte, vol. 8, no. 3, 1979, p. 168-174. In German. Research supported by the Bundesministerium fuer Forschung und Technologie.

MAJS: /\*CATALYSTS/\*FUEL CELLS/\*NICKEL

MINS: / ENERGY TECHNOLOGY/ MICROSTRUCTURE/ OXIDATION/ REDUCTION (CHEMISTRY)/ THERMODYNAMIC PROPERTIES

ABA: M.E.P.

ABS: It is shown that undesirable oxidation reactions can be used in the quantitative evaluation of the catalyst for practical applications. Attention is given to the behavior of Raney catalysts in fuel cells and a more suitable measuring technique which offers a better insight into these processes. The reduction processes and oxidation reaction are investigated. Applications are presented and include an example emphasizing the suitability of the technique for samples of small specific surface. This involved determining that the area of nickel powder, resulting from the reduction of nickel oxalate, was 3.1 sq m/g. This would mean a diameter of 0.22 microns, assuming a spherical form, which agrees with results obtained in another manner.

80A11973 ISSUE 2 PAGE 243 CATEGORY 44 79/00/00  
3 PAGES UNCLASSIFIED DOCUMENT

UTTL: The reality of on-site fuel cells

AUTH: A/SPERBERG, R. T.; B/FIORE, V. B. In: Energy technology VI: Achievements in perspective. Proceedings of the Sixth Conference, Washington, D.C., February 26-28, 1979. (ABO-11953 02-44) Washington, D.C., Government Institutes, Inc., 1979, p. 808-810.

MAJS: /\*COST ESTIMATES/\*ECONOMIC FACTORS/\*ENERGY POLICY/\*FUEL CELLS/\*TECHNOLOGY UTILIZATION

MINS: / ENERGY TECHNOLOGY/ PHOSPHORIC ACID/ PRODUCT DEVELOPMENT/ RESEARCH MANAGEMENT/ TECHNOLOGICAL FORECASTING

ABA: F.G.M.

ABS: On-site phosphoric acid fuel-cell systems are considered. The electrical efficiency of such a cell is shown to be 40% and to be increased to about 80% with waste-heat recovery. Applications of on-site fuel cells with heat recovery coupled with heat pumps are discussed, along with the current objectives of research on phosphoric acid fuel cells.

79A49489 ISSUE 22 PAGE 4182 CATEGORY 44  
79/08/00 20 PAGES UNCLASSIFIED DOCUMENT

UTTL: The theory of stabilization of the output power of a rechargeable fuel cell battery under conditions of significant concentration polarization

AUTH: A/GUREVICH, I. G. PAA: A/(Akademia Nauk Belorusskoi SSR, Institut Teplo- i Massootbmena, Minsk, Belorussian SSR) Journal of Power Sources, vol. 4, Aug. 1979, p. 145-164.

MAJS: /\*ELECTRIC POTENTIAL/\*ELECTROCHEMICAL CELLS/\*ELECTROLYTIC CELLS/\*FUEL CELLS/\*POWER EFFICIENCY/\*SYSTEMS STABILITY

MINS: / CONTINUUM FLOW/ ELECTRIC BATTERIES/ ENERGY DISSIPATION/ OPTIMIZATION/ POLARIZATION CHARACTERISTICS/ STABILIZATION

ABA: (Author)

ABS: A theory is developed for the output power stabilization of a rechargeable fuel cell battery in which the reactants and the electrochemical reaction products are in the electrolyte. Possible means of voltage stabilization are considered which employ continuous-flow and continuous flow-circulation supply of the working solution (electrolyte) to a fuel cell. Expressions are derived for the effective stabilization time and the required electrolyte flow rate. For a battery with known output parameters, the means of stabilization have been optimized based on the electrolyte flow rate and time of stabilization. The optimum solution is shown to depend on the net energy losses in implementing the stabilization procedure.

Fuel cells: In Pursuit of the Ideal Power Plant  
by L.A. Kilar

Power, Vol. 123, No. 5, May 1979, p. 37-39

**Harnessing tomorrow's energy**  
sources gets increasingly urgent  
priority as reserves of conventional  
fuels dwindle. Article examines po-  
tential and problems attending so-  
lar and wind energy and fuel cells,  
suggests the promise of solar en-  
ergy appears best for both utility and  
industrial plants

79A49750# ISSUE 17 PAGE 3237 CATEGORY 44  
79/00/00 19 PAGES UNCLASSIFIED DOCUMENT

UTTL: Fuels cells - Their development and potential  
AUTH: A/BELANGER, G. PAA: A/(Hydro-Quebec, Institut de  
Recherche, Varennes, Canada)  
In: Chemistry for energy: Proceedings of the  
Symposium, Winnipeg, Manitoba, Canada, June 5-7, 1978.  
(A79-40736 17-44) Washington, D.C., American Chemical  
Society, 1979, p. 303-321.  
MAJS: /\*FUEL CELLS/\*HYDROGEN OXYGEN FUEL CELLS/\*RESEARCH AND  
DEVELOPMENT/\*TECHNOLOGY ASSESSMENT  
MINS: / CANADA/ ELECTROCATALYSTS/ ELECTROCHEMISTRY/  
ELECTRODES/ ELECTROLYTES/ ENERGY TECHNOLOGY/ GRAPHS  
(CHARTS)/ POLARIZATION (CHARGE SEPARATION)/ REACTION  
KINETICS/ TABLES (DATA)/ THERMODYNAMIC EFFICIENCY  
S.D.  
ABA:  
ABS: The fuel cell is an energy conversion device that  
converts the free energy change of a chemical reaction  
directly into electrical energy, the conversion  
occurring by two electrochemical half-cell reactions.  
This conversion is not subject to the Carnot cycle  
limitations and is thus theoretically more efficient  
than a heat-based process. The paper discusses the  
thermodynamic principles of fuel cells, along with the  
kinetic aspects of their half-cell reactions. The  
fundamental problem of electrocatalysis is considered.  
Different types of fuel cells are described, and the  
current status of this new power-generating device is  
outlined. Present R&D efforts are discussed relative  
to moderate-temperature fuel cells, high-temperature  
systems, and Canadian contributions.

N80-14526# Los Alamos Scientific Lab., N. Mex.  
**APPLICATIONS OF FUEL CELLS IN TRANSPORTATION**  
B. McCormick, R. Bobbett, D. Lynn, S. Nelson (DOE, Washington,  
D.C.), S. Srinivasan (Brookhaven National Lab.), and J. McBrean  
(Brookhaven National Lab.) 1979 11 p Presented at the  
14th Intersoc. Energy Conversion Conf., Boston, 5-10 Aug.  
1979  
(Contract W-7405 eng-36)  
(LA-UR-79-628; CONF-790803-16) Avail: NTIS  
HC A02/MF A01

A detailed technical and economic evaluation of potential  
applications for fuel cells in transportation is given. Four vehicle  
types were evaluated: city bus, highway bus, delivery van, and  
consumer car, using fuel cell and reformer data. Various fuel  
options and performance vs economic tradeoffs were considered  
and final recommendations are presented. DOE

## FUEL CELL ENERGY GENERATORS.

Chemtech, vol 9, no 10, October 1979, p. 633-637.

N79-33581# United Technologies Corp., South Windsor, Conn.  
Power Systems Div.  
**ADVANCED TECHNOLOGY LIGHT WEIGHT FUEL CELL  
PROGRAM Final Report, 9 May 1977 - 16 Jun. 1978**  
R. E. Martin 16 Jun. 1978 73 p refs  
(Contracts NAS3-20621; NAS3-20604)  
(NASA-CR-159653; FCR-1017) Avail: NTIS  
HC A04/MF A01 CSCL 10A

A high performance hydrogen-oxygen alkaline fuel cell was  
investigated. Cell performance goals include: 0.9 volts at a current  
density of 1000 amperes per sq ft for 3000 hours at a cell  
temperature up to 300 F and reactant pressure up to 250 psia.  
Subscale research cells were tested in the evaluation of five  
anode and five cathode catalyst configurations. Fuel cell matrices  
were fabricated from NASA supplied polybenzimidazole (PBI)  
powder. A cell edge frame and PBI matrix samples were corrosion  
tested in 42 wt% KOH at 250 F (121 C). A total of 13,828 hours  
of research cell testing at 250 F was completed. In addition  
494 hours of testing at temperatures up to 300 F and reactant  
pressures up to 250 psia with 27 hours of operation at or  
above 0.9 V/c at 1000 ASF was completed. A supported  
platinum-on-carbon catalyst configuration demonstrated stable  
operation at high temperature. A new cell edge frame structure  
showed low weight loss during corrosion testing, an indication  
of the material stability and long life potential. J.M.S.

**FUEL-CELL POWER PLANTS**, by Arnold P. Fickett.  
Scientific American, vol. 239, no. 6, December  
1978, p. 70-76.

Over the next decade electric utilities in the U.S. will require power generators that fulfill certain unusual requirements: high efficiency, low emission of pollutants, quiet operation and quick installation. The generators must be able to supply electricity in urban areas where conventional generators would be unacceptable for environmental reasons. A likely candidate is the fuel cell.



79N21556# ISSUE 12 PAGE 1590 CATEGORY 44 RPT#:  
CONS/1197-9 CNT# EY-76-C-03-1197 78/03/31 226  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Thin film battery/fuel cell power generating system  
TLSP: Final Report, Apr. 1976 - Apr. 1978  
CORP: Westinghouse Research and Development Center,  
Pittsburgh, Pa. AVAIL NTIS SAP: HC A11/MF A01  
MAJS: /\*ELECTRIC BATTERIES/\*ELECTRIC GENERATORS/\*ENERGY  
STORAGE/\*FUEL CELLS/\*THIN FILMS/\*VAPOR DEPOSITION  
MINS: / CHROMITES/ COMPOSITE MATERIALS/ ELECTRIC POTENTIAL/  
ELECTRICAL RESISTIVITY/ ELECTROCHEMISTRY/ ELECTRODES/  
ELECTROLYTES/ FABRICATION/ PIPES (TUBES)/ SPUTTERING/  
THERMAL EXPANSION/ ZIRCONIUM  
ABA: L.P.  
ABS: A rare-earth chromite was identified and synthesized  
by RF sputtering. It was tested for resistivity,  
thermal expansion and inertness in contact with  
yttria-stabilized zirconia, and was used as an  
interconnection material. Films of these  
interconnection materials were successfully deposited  
onto stabilized zirconia tubes by electrochemical  
vapor deposition. This technique was used to fabricate  
such films in building fuel cell stacks. Tin-doped  
indium oxide and antimony-doped tin oxide air  
electrode current collector materials were  
successfully chemically vapor deposited, as thin  
films, onto zirconia tubes. An in-house extrusion  
technology for porous calcia-stabilized zirconia tubes  
were developed and used to provide suitable support  
tubes for component combination samples, unit cell and  
cell stack sample preparation.

80N14523# ISSUE 5 PAGE 621 CATEGORY 44 RPT#:  
CONF-7809137-1 CNT# EM-78-C-03-1735 78/10/00 13  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Fuel cell option  
AUTH: A/BLURTON, K. F.  
CORP: Institute of Gas Technology, Chicago, Ill.  
AVAIL NTIS SAP: HC A02/MF A01  
Presented at Conf. on Nat. Energy Econ. 2, Tulsa,  
Okla., 18-20 Sep. 1978  
MAJS: /\*ENERGY TECHNOLOGY/\*FUEL CELLS/\*TECHNOLOGY  
UTILIZATION  
MINS: / CHEMICAL ENERGY/ ENERGY CONVERSION EFFICIENCY/ POWER  
PLANTS  
ABA: DOE  
ABS: Fuel cell technology and its potential application is  
discussed. The strategy of fuel cell development is

examined and the attributes of fuel cell power plants  
are described.

78A32235 ISSUE 12 PAGE 2197 CATEGORY 44  
78/03/00 15 PAGES UNCLASSIFIED DOCUMENT

UTTL: 25 years of fuel cell development /1951-1976/  
AUTH: A/KORDESCH, K. V. PAA: A/(Union Carbide Corp.,  
Battery Products Div., Parma, Ohio)  
Electrochemical Society, Journal, vol. 125, Mar. 1978,  
p. 77C-91C.  
MAJS: /\*CHRONOLOGY/\*ELECTRIC BATTERIES/\*ELECTRODES/\*FUEL  
CELLS/\*TECHNOLOGY ASSESSMENT  
MINS: / APOLLO PROJECT/ ELECTROLYTIC CELLS/ ENERGY  
TECHNOLOGY/ POROUS MATERIALS  
ABA: M.L.  
ABS: Areas of fuel cell research during the '50s are  
indicated and the recognition of the need for a stable  
large interface between electrode and electrolyte is  
credited with causing the sudden breakthrough in  
technology. A chronological survey of fuel cell  
systems is presented; fuel cells considered include  
high-temperature cells (molten carbonate cells),  
medium-temperature fuel cells (modifications of the  
Bacon cell), fuel cells with platinum black Teflon  
electrodes, fuel cells with porous metal electrodes,  
ion-exchange membrane cells, matrix (phosphoric acid)

fuel cells, acidic methanol cells, alkaline cells with  
methanol or methanol-derived fuels, ammonia as fuel,  
sodium amalgam cells, regenerative H<sub>2</sub>-O<sub>2</sub> fuel cell  
systems, thermally regenerative systems, radioactive  
regenerative fuel cells, chemical redox systems, the  
nitric acid-oxygen redox electrode, biochemical cells,  
direct hydrocarbon cells, and indirect hydrocarbon  
cells.

FUEL - CELL TRIALS: UTILITIES NOW, CPI NEXT?  
John C. Davis

Chemical Engineering, Vol. 85, No. 18, August  
14, 1978, p. 79-81.

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As the time approaches for tests of the first megawatt-range  
system, fuel-cell developers are busy tackling engineering  
problems and applications studies. One such report shows  
that the cells could pay off in CPI installations.

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HASA CP-2058 Fuel cells 1978

FUTURE ORBITAL POWER SYSTEMS TECHNOLOGY REQUIREMENTS.  
(Symposium held LeRC, May 31-June 1, 1978). Sept. 1978.  
322p.

Symposium on Future Orbital Power May 31-June 1,  
Systems Technology Requirements 1978.

TECHNOLOGY STATUS - BATTERIES AND FUEL CELLS  
J. Stuart Fordyce, NASA Lewis Research Center p. 157.

TECHNOLOGY STATUS - FUEL CELLS AND ELECTROLYSIS CELLS  
Hoyt McBryar, NASA Johnson Space Center . p. 167.

BATTERY WORKSHOP . . . p. 283 . . . . .  
FUEL CELL/ELECTROLYZER WORKSHOP p. 289 . . . . .

THE THEORETICAL ENERGY CONVERSION EFFICIENCY OF A  
HIGH TEMPERATURE FUEL CELL BASED ON A MIXED CONDUCTOR.  
D.S. Tannhauser.

J. Electrochem. Soc., v.125, no.8, Aug. 1978, p.1277-82.

We have calculated the voltage vs. current characteristic and the energy conversion efficiency of a fuel cell based on a mixed ionic-electronic conductor. The transport equations for the electrolyte are solved exactly and the material parameters which determine the shape of the characteristic are determined. The equations are then applied to the special case of doped ceria, which becomes a mixed conductor only at low oxygen pressures. We then show that for the purpose of efficiency calculations, the finite but small ratio of ionic to electronic mobility valid for ceria can be safely taken as zero, and we compare the resulting simple equations with the equivalent circuit approach to a fuel cell. The characteristic is found to be curved instead of being a straight line and for typical operating conditions the best energy conversion efficiency is, for the transport theory approach, 50% higher than for the equivalent circuit one. We conclude from the calculated new values of conversion efficiency that the equivalent circuit underestimates the conversion efficiency of a mixed conductor seriously and that doped ceria as a solid electrolyte is a more serious contender to doped zirconia than believed up to now.

ECONOMIC ASSESSMENT OF THE UTILIZATION OF FUEL CELLS  
IN ELECTRIC UTILITY SYSTEMS, by William Wood,  
Paul Yatchko, and M. P. Bhavaraju.  
IEEE Transactions on Power Apparatus and Systems,  
vol. PAS-97, no. 5, Sept/Oct 1978, p. 1805-1813.

**Abstract** - This paper evaluates the long range economic benefits of first generation and advanced fuel cells in the future generation capacity plans of a representative electric utility system. The economic benefits of fuel cells' unique characteristics are separately quantified and the relationships between market penetration, fuel price, and capital cost are analyzed. Reliability, production cost, and optimum generation mix methods commonly used for generation planning in utilities were used for this study.

A GIANT STEP PLANNED IN FUEL-CELL PLANT TEST,  
by Edward P. Barry, Roosevelt L. A. Fernandes,  
and William A. Messner.

IEEE Spectrum, vol. 15, no. 11, November 1978,  
p. 47-53. The day when electric energy will be supplied by fuel cells has been brought a step closer to realization. In August, shortly after it was awarded a contract by the U.S. Department of Energy's (DOE) Energy Research and Development Agency and the Electric Power Research Institute (EPRI), the Consolidated Edison Company of New York began a joint Government/electric utility program to install and operate a prototype 4.8-MW dc or 4.5-MW ac fuel-cell module on its electrical system. The module is being manufactured by the United Technologies Corporation (UTC). This demonstration program is the first effort to apply the fuel-cell concept in a utility environment, and to quantify and evaluate benefits that might accrue to electric utilities and their customers through its use.

OC Power Sources Symposium, 28th, Atlantic  
603 City, N.J., 1978.  
.96 Proceedings of the 28th Power Sources  
1978 Symposium, 12-15 June 1978 / sponsored by  
Power Sources Division, Electronics Tech-  
nology & Devices Laboratory, U.S. Army  
Electronics Research & Development Command,  
Fort Monmouth, N.J. -- Princeton, N.J.

**An Assessment of the Solid Polymer Electrolyte Fuel Cell for Mobile Power Plants**

J. F. McElroy, <i>General Electric Company</i> . . . P.32 . . . . .	32
<b>1 kW Tungsten Carbide Fuel Cell Power Plant with a Methanol Cracker</b>	
K. P. Maass, <i>AEG-TELEFUNKEN</i> . . . . P.35 . . . . .	35
<b>1.5-kW Methanol Fuel Cell Power Plant System Design Study</b>	
A. P. Meyer, <i>United Technologies Corporation</i> . . . P.37 . . . . .	37

**ECAS PHASE I FUEL CELL RESULTS**

Marvin Warshay  
J. of Energy  
Vol. 2 no. 1 January-February 1978  
p. 46-52

This paper summarizes and discusses the fuel cell system results of Phase I of the Energy Conversion Alternatives Study (ECAS). Ten advanced electric powerplant systems for central-station baseload generation using coal were studied by NASA in ECAS. Contractors for Phase I, the parametric analysis, were General Electric and Westinghouse. Three types of low-temperature fuel cells [solid polymer electrolyte (SPE), aqueous alkaline, and phosphoric acid] and two types of high-temperature fuel cells [molten carbonate (MC) and zirconia solid electrolyte (SE)] were studied. The results indicate that 1) overall efficiency increases with fuel cell temperature and 2) scale-up in powerplant size can produce a significant reduction in cost of electricity (COE) only when it is accompanied by utilization of waste fuel cell heat through a steam bottoming cycle and/or integration with a gasifier. For low-temperature fuel cell systems, the use of hydrogen results in the highest efficiency and lowest COE.

**BATTERY AND FUEL CELL TECHNOLOGY SURVEYED.**

Thomas J. Lund & Joseph F. McCartney  
Automotive Engineering, Vol. 86, No. 7,  
July 1978, p. 68-72.

*The future of the electric vehicle depends on advancement of battery technology. This article discusses leading-edge battery developments and fuel cells for special-purpose vehicle power.*

BON70587# CATEGORY 44 RPT#: EPRI-EM-695-VOL-2  
78/03/00 315 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Assessment of fuels for power generation by electric  
utility fuel cells, volume 2 TLSP: Final Report  
AUTH: A/STICKLES, R. P.; B/INTERESS, E.; C/MONCRIEFF, T.  
I.  
CORP: Little (Arthur D.), Inc., Cambridge, Mass.  
AVAIL: NTIS  
MAJS: /\*ELECTRIC POWER PLANTS/\*ENERGY POLICY/\*FUEL CELLS/\*  
UTILITIES  
MINS: / COAL/ COST ESTIMATES/ CRUDE OIL/ ENERGY TECHNOLOGY/  
NATURAL GAS

A79-40750 # Fuels cells - Their development and potential.  
G. Bélanger (Hydro-Québec, Institut de Recherche, Varennes,  
Canada). In: Chemistry for energy; Proceedings of the Symposium,  
Winnipeg, Manitoba, Canada, June 5-7, 1978. (A79-40736 17-44)  
Washington, D.C., American Chemical Society, 1979, p. 303-321, 26  
refs.

The fuel cell is an energy conversion device that converts the free energy change of a chemical reaction directly into electrical energy, the conversion occurring by two electrochemical half-cell reactions. This conversion is not subject to the Carnot cycle limitations and is thus theoretically more efficient than a heat-based process. The paper discusses the thermodynamic principles of fuel cells, along with the kinetic aspects of their half cell reactions. The fundamental problem of electrocatalysis is considered. Different types of fuel cells are described, and the current status of this new power-generating device is outlined. Present R&D efforts are discussed relative to moderate-temperature fuel cells, high-temperature systems, and Canadian contributions. S.D.

N80 15613# Institute of Gas Technology, Chicago, Ill.  
**PREDICTION OF CURRENT DISTRIBUTION IN A MOLTEN CARBONATE FUEL CELL**  
V. Sampath, J. R. Selman, and A. F. Sammells. 1978 30 p  
refs. Presented at the 2d Intern. Symp. on Molten Salts, Pittsburgh,  
15-20 Oct. 1978. Sponsored by the Electrochem. Soc., Inc.  
(Contract EM-78-C-03-1735)  
(CONF-781063-1) Avail. NTIS HC A03/MF A01

A mathematical model was developed to predict the performance of a molten carbonate fuel cell as a function of

77A48735 ISSUE 23 PAGE 3981 CATEGORY 44  
77/00/00 5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Advanced fuel cell technology and applications

AUTH: A/KING, J. M.; B/HOUGHIBY, W. E.; C/SEDERQUIST, R. A.  
PAA: C/(United Technology Corp., Power Systems Div., South Windsor, Conn.)

In: Intersociety Energy Conversion Engineering Conference, 12th, Washington, D.C., August 28-September 2, 1977. Proceedings, Volume 1. (A77-48701 23-44) La Grange Park, Ill., American Nuclear Society, Inc., 1977, p. 325-329.

MAJS: /\*FUEL CELLS/\*RESEARCH AND DEVELOPMENT/\*TECHNOLOGY ASSESSMENT

MINS: / CARBONATES/ ENERGY CONVERSION EFFICIENCY/ GAS TURBINES/ PHOSPHORIC ACID/ STEAM TURBINES

ABA: (Author)

ABS: The Advanced Technology Fuel Cell Program objective is to establish the technology and design base for fuel cell powerplants with reduced capital cost, a 7500 BTU/kWh heat rate and fuel capability extending to Number 2 fuel oil. Molten carbonate, advanced phosphoric acid fuel cells, and advanced fuel processing concepts are being investigated and approaches to the use of coal with fuel cell powerplants are under evaluation. A low cost concept was demonstrated in a 20-cell phosphoric acid stack. Subscale molten carbonate cell performance and endurance have improved significantly. A 19-cell stack test confirmed the ability to scale molten carbonate cells. An advanced reforming laboratory rig operated stably for 1000 hours on No. 2 fuel oil with 2500 ppm sulfur. Coal-fueled concepts have been investigated for central stations. Studies indicate coal pile-to-bus bar efficiencies of 45-50% can be achieved.

77V35476 1977 ISS: 70 TK.2920.USB

JTTL: Fuel cells: a bibliography.

U. S. Energy Research and Development Administration. Technical Information Center.

National Technical Information Service, Springfield, Va., 246, 164 p.

U. S. Energy Research and Development Administration. TID-3359

LC: Fuel cells--Bibliography.

NASA: / BIBLIOGRAPHIES/ ENERGY SOURCES/ FUEL CELLS

MAIN-CORP TRACE-SERS\*ITL\* CATLG BY-JOHNSON

77/08/10 REFERENCE AVAIL: / JOHNSON

79A14947\*# ISSUE 3 PAGE 424 CATEGORY 44  
77/11/00 24 PAGES UNCLASSIFIED DOCUMENT

UTTL: Fuel cell on-site integrated energy system parametric analysis of a residential complex

AUTH: A/SIMONS, S. N. PAA: A/(NASA, Lewis Research Center, Cleveland, Ohio)

CORP: National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

U.S. Department of Energy, Fuel Cell Workshop, Sarasota, Fla., Nov. 14-17, 1977. Paper, 24 p.

MAJS: /\*BUILDINGS/\*ELECTRIC POWER PLANTS/\*ENERGY REQUIREMENTS/\*FUEL CELLS/\*PHOSPHORIC ACID/\*RESIDENTIAL AREAS

MINS: / DOMESTIC ENERGY/ ENERGY TECHNOLOGY/ MODULAR INTEGRATED UTILITY SYSTEM/ TABLES (DATA)/ THERMODYNAMIC EFFICIENCY/ WATER TEMPERATURE

ABA: M.L.

ABS: The use of phosphoric acid fuel cell powerplant to provide all the electricity required by an 81-unit garden apartment complex is studied. Byproduct heat is recovered and provides some of the heat required by the complex. The onsite integrated energy system contains energy conversion equipment including combinations of compression and absorption chillers, heat pumps, electric resistance heaters, and thermal storage. The annual fuel requirement for several onsite integrated energy systems as well as the fuel cell breakeven cost for one specific system were calculated. It is found that electrical efficiency cannot be traded off against thermal efficiency without paying a penalty in system efficiency.

TK  
2931  
.F78

Fuel cells for public utility and industrial power / edited by Robert Noyes. — Park Ridge, N.J. : Noyes Data Corp., 1977.

x, 322 p. : ill. ; 24 cm. — (Energy technology review ; no. 18)

Includes bibliographical references.

1. Fuel cells—Addresses, essays, lectures. 2. Fuel cells—Patents—Addresses, essays, lectures. I. Noyes, Robert. II. Series.



78N27553# ISSUE 18 PAGE 2412 CATEGORY 44 RPT#:  
EPRI-EM-576 77/11/00 78 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Advanced technology fuel cell program TLSP: Interim Report  
AUTH: A/KING, J. M., JR.  
CORP: United Technologies Corp., South Windsor, Conn.  
AVAIL NTIS SAP: HC A05/MF A01  
MAJS: /\*ENERGY CONVERSION/\*ENERGY POLICY/\*ENERGY TECHNOLOGY  
/\*FUEL CELLS  
MINS: / ADIABATIC CONDITIONS/ COAL UTILIZATION/ METHANE/  
MOLTEN SALT ELECTROLYTES/ PHOSPHORIC ACID  
ABA: ERA  
ABS: Molten carbonate fuel cells, advanced phosphoric acid  
fuel cells, advanced fuel processors and the use of  
coal and coal products in central stations or  
dispersed fuel cell powerplants are under  
investigation. Molten carbonate fuel cell activities  
focused on reactant containment, increased endurance,  
and improved performance. The effort is continuing to  
demonstrate cell performance and function for extended  
periods at the cell stack level. An advanced  
phosphoric acid cell concept, with potential for  
reduced cost and reduced resistance losses, was  
demonstrated in a 20-cell stack. The best performing  
cells achieved expectations, and the concept was  
successfully demonstrated. Investigations showed that  
adiabatic steam reforming holds promise for processing  
No. 2 fuel oil in dispersed fuel cell generators, and  
subscale testing was conducted to establish acceptable  
operating conditions.

TJ Energy development III ... cl 77. (Card 2)  
153 Includes bibliographic references.  
.E4783 1. Power resources—Congresses.  
pt.3 2. Electric power—Congresses. I.  
IEEE Power Engineering Society. IEEE  
Power Generation Committee. Energy Develop-  
ment Subcommittee. II. Series.

Hybrid Simulation of Fuel Cell Power Conversion Systems,  
by L. H. Michaels, B. T. Fairchild and S. T. Kohn.... p. 34.....

Hydrogen Cycle Peak-Shaving on the New York State Grid Using Fuel Cells,  
by R. A. Fernandes and H. D. Philipp.... p. 42.....

79A11814 ISSUE 2 PAGE 266 CATEGORY 44 77/00/00  
14 PAGES UNCLASSIFIED DOCUMENT

UTTL: ERDA fuel cell programs  
AUTH: A/LAWRENCE, L. R., JR. PAA: A/U.S. Department of  
Energy, Div. of Conservation, Research and Technology,  
Washington, D.C.)  
In: Symposium on Electrode Materials and Processes for  
Energy Conversion and Storage, Philadelphia, Pa., May  
9-12, 1977, Proceedings. (A79-11776 02-25) Princeton,  
N.J., Electrochemical Society, Inc., 1977, p. 593-606.  
MAJS: /\*DOMESTIC ENERGY/\*ELECTRIC POWER PLANTS/\*FUEL CELLS/\*  
RESEARCH AND DEVELOPMENT/\*TECHNOLOGY ASSESSMENT  
MINS: / ENERGY CONSERVATION/ ENERGY POLICY/ ENERGY  
TECHNOLOGY/ FUELS/ NATURAL GAS/ PROJECT PLANNING/  
TECHNOLOGY UTILIZATION/ WASTE ENERGY UTILIZATION  
ABA: M.L.  
ABS: Program objectives for first and second generation  
fuel cells are discussed. Advantages of fuel cell  
systems include siting flexibility, modularity, and  
multifuel capability, and oil savings resulting from  
the use of fuel cells are considered. A demonstration  
first-generation 4.6-MW fuel cell power system has  
been prepared, and ERDA research interests such as  
utility demonstrations, fuels utilization, and systems  
development are surveyed.

77A31171 ISSUE 13 PAGE 2207 CATEGORY 44  
77/04/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Anodic oxidation of ethylene glycol with noble metal  
alloy catalysts --- in fuel cell  
AUTH: A/KOHLMUELLER, H. PAA: A/(Siemens AG,  
Forschungslaboratorien, Erlangen, West Germany)  
Journal of Power Sources, vol. 1, Apr. 1977, p.  
249-256. Research supported by the Bundesministerium  
der Verteidigung.  
MAJS: /\*CATALYSTS/\*CELL ANODES/\*ELECTROCHEMICAL CORROSION/\*  
FUEL CELLS/\*GLYCOLS/\*OXIDATION  
MINS: / ACTIVATION ENERGY/ CATALYTIC ACTIVITY/ ELECTROLYTIC  
CELLS/ ETHYLENE COMPOUNDS/ NOBLE METALS/ PLATINUM/  
VOLT-AMPERE CHARACTERISTICS  
ABA: G.R.  
ADS: Current-voltage curves showing the corrosion of  
platinum-lead alloys in 6 M KOH were obtained, taking  
into account the intermetallic compound Pt5Pb. The  
activity of Raney-platinum and platinum-lead alloys is  
discussed. Attention is given to the determination of  
the apparent energy of activation, the determination  
of the current function, and platinum-lead catalysts  
in fuel cell electrodes.

78N30067# ISSUE 21 PAGE 2837 CATEGORY 44 RPT#:  
ANL-77-56 CNT#: W-31-109-ENG-38 77/08/00 22 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Advanced fuel cell development TLSP: Progress  
Report, Apr. - Jun. 1977  
AUTH: A/ACKERMAN, J. P.; B/KINOSHITA, K.; C/SIM, J. W.;  
D/SWAROOP, R.; E/NELSON, P. A.  
CORP: Argonne National Lab., Ill. AVAIL:NTIS SAP: HC  
A02/MF A01  
MAJS: /\*CARBONATES/\*ELECTROLYTES/\*FUEL CELLS  
MINS: / ANODES/ CATHODES/ RESEARCH AND DEVELOPMENT/  
STAINLESS STEELS  
ABA: ERA  
ABS: Efforts were directed toward understanding and  
improvement of molten-carbonate-electrolyte fuel cells  
operating at temperatures near 923 K. A primary focus  
of the work was on developing electrolyte structures  
which have high strength and conductivity, as well as  
good electrolyte retention, and on developing methods  
of synthesis for electrolyte structures that are  
amenable to mass production. A low temperature  
synthesis which produces material having rodlike  
particles of beta-LiAlO<sub>2</sub> was refined and is now used  
for preparing electrolytes. Cell testing is essential  
for understanding and evaluating individual component  
behavior and the interactions of the components under  
realistic operating conditions. Most of the testing to  
date was conducted in a 7-cm (2 3/4-in.)-dia  
cylindrical cell with Type 316 stainless steel  
 housings and current collectors, a nickel anode, and a  
nickel oxide cathode.

TJ New options in energy technology ... cl977.  
163.2 (Card 2)  
.N47

**I. American Institute of Aeronautics  
and Astronautics, II. Edison Electric  
Institute, III. Institute of Electrical  
and Electronics Engineers, Power Engi-  
neering Society.**

Improvement in Phosphoric Acid Fuel Cell Powerplant Technology - L. M.  
HANDLEY, P. E. GREVSTAD, D. R. McVAY.....p.41

Economic Assessment of the Utilization of Fuel Cells in Electric Utility  
Systems - W. Wood, M. P. BHAVARAJU, P. YATCKO, A. P. FICKETT.....p.51

77A41559# ISSU# 19 PAGE 3244 CATEGORY 44 RPT#:  
AIAA 77-1012 77/00/00 11 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Economic assessment of the utilization of fuel cells  
in electric utility systems  
AUTH: A/WOOD, W.; B/BHAVARAJU, M. P.; C/YATCKO, P.;  
D/FICKETT, A. P. PAA: C/(Public Service Electric and  
Gas Co., Newark, N.J.); D/(Electric Power Research  
Institute, Palo Alto, Calif.)  
In: New options in energy technology: Proceedings of  
the Conference, San Francisco, Calif., August 2-4,  
1977. (A77-41551 19-44) New York, American Institute  
of Aeronautics and Astronautics, Inc., 1977, p. 51-61.  
MAJS: /\*COST EFFECTIVENESS/\*ECONOMIC ANALYSIS/\*ELECTRIC  
POWER PLANTS/\*ELECTRIC POWER SUPPLIES/\*FUEL CELLS/\*  
TECHNOLOGY ASSESSMENT  
MINS: / COST REDUCTION/ ENERGY TECHNOLOGY/ SYSTEMS  
ENGINEERING/ TECHNOLOGICAL FORECASTING/ UTILITIES  
ABA: (Author)  
ABS: The long range economic benefits of first generation  
and advanced fuel cells in the future generation  
capacity plans of a representative electric utility  
system are evaluated. The benefits of fuel cells'  
unique characteristics are separately quantified and  
the relationships between market penetration, fuel  
price, and capital cost are analyzed utilizing  
reliability, production cost, and optimum generation  
mix methods commonly used for generation planning in  
utilities.

**Fuel Cells: A Bibliography.**

Energy Research and Development Administration, Oak  
Ridge, Tenn. Technical Information Center. Jun 77, 416p  
TID-3359 Price code: PC A18

The compilation includes 3273 citations of foreign and  
domestic research reports, journal articles, patents, con-  
ference proceedings, and books published since the mid-  
1960s. Each complete bibliographic citation is followed by  
an abstract or a listing of the subject descriptors used to  
describe the content of the reference for machine storage  
and retrieval. Four indexes are provided: corporate, author,  
subject, and report number. The citations are arranged in  
subject categories: General; Design and Development;  
Performance and Testing; Materials, Components, and  
Auxiliaries; Applications; and Electrochemistry, Mass  
Transfer, and Thermodynamics. (E&A citation 02:045741)

QD Electrochemical Society.  
552 Extended abstracts, v. 77-1. Spring  
.E42 meeting, Philadelphia, Pennsylvania, May 8-  
1977 13, 1977. -- Princeton, N.J. : Electro-  
v.77-1 chemical Society, c1977.  
1027 p. : ill. ; 22 cm.

The ERDA Fuel Cell Program L. R. Lawrence, Jr.....	983	IC-
The State-of-the-Art of Hydrogen-Air Phosphoric Acid Electrolyte Fuel Cells H. R. Ruiz.....	985	)
Analysis of Electrolyte Shunt Currents in Fuel Cell Powerplants M. Katz.....	989	
Molten Carbonate Fuel Cell Systems - Status and Potential J. P. Ackerman.....	992	
Effects of Sintering on Porous Fuel Cell Electrodes K. Kinoshita.....	995	
Partial Processes and Transport Parameters in Molten Carbonate Fuel Cell Operation J. R. Selman, H. C. Maru, and L. G. Marianowski.....	998	
Thin Film High Temperature Solid Electrolyte Fuel Cells A. O. Isenberg.....	1000	
Electrochemical Characteristics of $ZrO_2-Y_2O_3$ Solid Electrolytes for Fuel Cells H. S. Isaacs and P. G. Russell.....	966	
Electrochemistry of Lithium/Metal Sulfide and Calcium/ Metal Sulfide Cells Using Molten Salt Electrolytes R. K. Steunenberg and M. F. Roche.....	968	
Fuel Cell Electrocatalysis: Where Have We Failed? A. P. Pickett.....	957	

# ETHYLENE GLYCOL AS FUEL FOR ALKALINE FUEL CELLS.

H. Ewe, E. Justi, and M. Pesditschek

Energy Conversion, 1977, vol. 15, no. 1/2,  
p. 9-14

TK  
2896  
.I55  
1977  
V.1

Intersociety Energy Conversion Engineering  
Conference, 12th, Washington, 1977.  
Proceedings of the 12th Intersociety  
Energy Conversion Engineering Conference,  
Washington, D. C., August 29 through  
September 2, 1977. -- La Grange, Ill. :

779047 — Aluminum-Based Anodes for Under- water Fuel Cells, H. B. Urbach, M. C. Cervi, Naval R & D Center, Carderock, Md. ....	276
J. Parry, Arthur D. Little, Inc., Cambridge, Mass.	
779053 — ERDA Fuel Cell Programs, L. R. Law- rence, Jr., ERDA, Washington, D.C. ....	319
779054 — Advanced Fuel Cell Technology and Ap- plications, J. M. King, Jr., W. E. Houghtby, R. A. Sederquist, United Technologies Corp., South Windsor, Conn. ....	325
779055 — ERDA Fuel Cell Applied Research Pro- gram, I. L. Harry, ERDA, Washington, D.C. ...	330
779056 — Molten Carbonate Fuel Cell Model, D. J. Dharia, Energy Research Corp., Danbury, Conn. ....	337
779057 — 4.8-Megawatt Fuel Cell Module Dem- onstrator, L. M. Handley, United Technologies Corp., South Windsor, Conn.; I. J. Rogers, ERDA, Washington, D.C.; E. Gillis, EPRI, Palo Alto, Calif. ....	341

## METHANOL - AIR FUEL CELL WITH HYDROPHILIC AIR ELECTRODES.

C. L. Sylwan

Energy Conversion, Vol. 17, No. 2/3, 1977,  
p. 67-72.

**Abstract**—A methanol-air fuel cell system with alkaline electrolyte and hydrophilic air electrodes was built and tested. Heat and fuel losses as well as auxiliary system power demand have been measured. Information is gained about attainable temperatures and voltage efficiencies as a function of the number of cells delivering a given electrical output. The effects of some stack imperfections are discussed.



79A11815 ISSUE 2 PAGE 266 CATEGORY 44 77/00/00  
14 PAGES UNCLASSIFIED DOCUMENT

UTTL: The state-of-the-art of hydrogen-air phosphoric acid electrolyte fuel cells

AUTH: A/KUNZ, H. R. PAA: A/(United Technologies Corp., Power Systems Div., South Windsor, Conn.)  
In: Symposium on Electrode Materials and Processes for Energy Conversion and Storage, Philadelphia, Pa., May 9-12, 1977. Proceedings. (A79-11776 02-25) Princeton, N.J., Electrochemical Society, Inc., 1977, p. 607-620.

MAJS: /\*ELECTROLYTES/\*FUEL CELLS/\*PHOSPHORIC ACID/\*  
TECHNOLOGY ASSESSMENT

MINS: / CATALYTIC ACTIVITY/ ELECTRIC POWER PLANTS/ FOSSIL FUELS/ HYDROGEN/ OXIDATION/ PLATINUM/ REDUCTION (CHEMISTRY)/ SURFACE REACTIONS

ABA: M.L.

ABS: The use of phosphoric acid fuel cell stacks in conjunction with fossil fuel powerplants which produce a hydrogen-rich gas is considered. Characteristics of the electrolyte fuel cells are discussed with attention to the activity of platinum for oxygen reduction and for hydrogen oxidation. Decay mechanisms are surveyed. The phosphoric acid cell operates at approximately 190 C; performance is unaffected by CO<sub>2</sub> in the fuel, but CO causes anode poisoning.

78A18624 ISSUE 5 PAGE 826 CATEGORY 44 77/12/00  
9 PAGES UNCLASSIFIED DOCUMENT

UTTL: Exotic power and energy storage

AUTH: A/SURFACE, M. O.

Power Engineering, vol. 81, Dec. 1977, p. 36-44.  
S.C.S.

ABA: S.C.S.  
ABS: Consideration is given to a variety of near-term energy storage systems, including both conventional and underground hydro-pumped storage, compressed air storage for combustion turbines, thermal energy storage in central power plants, and the lead-acid battery. Potential intermediate-term systems, which may be developed during the 1985-2000 period, are identified, such as advanced batteries, flywheel storage, and hydrogen storage. The concept of direct electrical storage in superconducting magnets is suggested as a possible long-term storage system. It is noted that most alternative energy systems may be classified as either base-load power or variable systems. Attention is also given to base-load systems in conjunction with orbital power satellites, and to geothermal power plants, magnetohydrodynamics, and fuel cells.

QC  
603  
.P6  
1976

Power Sources Symposium, 27th, Atlantic City  
N.J., 1976.

[Proceedings] ... [1977] (Card 2)

#### Improved Acid Electrolytes for the Hydrocarbon-Air Fuel Cell

A. A. Adams, R. T. Foley, Department of Chemistry, American University, G. W.  
Electrochemical Division, MERADCOM ..... p. 172

#### A New Composite Electrocatalyst Material for H<sub>2</sub>PO<sub>4</sub> Fuel Cells

L. B. Welsh, R. W. Leyerle, G. L. Hervert and K. J. Youtsey, Corporate Research  
UOP Inc., M. A. George, Energy Research Corporation ..... p. 175

#### Low Power Methanol Fuel Cells

J. Perry, Jr., Power Sources Technical Area, U.S. Army Electronics Technology  
Laboratory (ECOM), M. Klein, Energy Research Corporation ..... p. 178

#### Hydrocarbon Fuel Conditioner for a 1.5 kW Fuel Cell Power Plant

Michael A. Callahan, U.S. Army Mobility Equipment R & D Command, Willard  
IIT Research Institute ..... p. 180

#### Phosphoric Acid Fuel Cell Stack Development

S. G. Abens, B. S. Baker, I. Michalko, Energy Research Corporation ..... p. 183

#### 1.5 kW Indirect Methanol-Air Fuel Cell Power Plant

Michael Onischak, Energy Research Corporation, Stanley S. Kurpit, U.S.A. ME ..... p. 186

#### OXIDATION OF METHANOL ON AGITATED BED ELECTRODES USING NON-METALLIC ELECTROCATALYSTS.

Kenneth J. W. Kurkowi and Colin R. Phillips

Energy Conversion, 1977, vol. 16, no. 3,  
p. 91-94

#### HEAT AND MASS TRANSFER ANALYSIS OF BACON-TYPE HYDROGEN-OXYGEN FUEL CELLS: THE VOLUME AVERAGE VELOCITY

Y. Bayazitoglu and G. E. Smith

International Journal of Hydrogen Energy, vol.  
2, no. 2, 1977, p. 139-155



79N17344# ISSUE 8 PAGE 1004 CATEGORY 44 RPT#:  
BMFT-FB-1-77-17 77/12/00 265 PAGES In GERMAN:  
ENGLISH summary UNCLASSIFIED DOCUMENT DCAF  
E002631

UTTL: Development of high temperature fuel cell battery  
TLSP: Final Report

AUTH: A/HOLICK, H.; B/KLEINSCHMAGER, H.; C/KRAPF, R.;  
D/MINOR, A.; E/ROHR, F. J.

CORP: Brown, Boveri und Cie, A.G., Heidelberg (West  
Germany). CSS: (Zentrales Forschungslab.)  
AVAIL: NTIS SAP: HC A12/MF A01; ZLDI, Munich DM 57.10  
Sponsored by Bundesmin. fuer Forsch. u. Technol.

ABA: G.Y.

ABS: Proceeding from the basic investigation of single  
cells, research work was performed with high  
temperature fuel cell batteries containing ZrO2 solid  
electrolytes. The main objective was to develop  
multicell modules and the associated joining  
technology as well as the development of auxiliary  
equipment for the operation of the batteries. Modules  
of 30 tube-shaped in-series connected cells and the  
subsequently built small battery units as well as the  
auxiliary equipment necessary for the reformation of  
natural gas were tested successfully at working  
temperatures of 1000 C. Experimental cells were  
operated for more than 22,000 hours at temperatures of  
1000 C and under permanent load. The decrease in  
voltage and performance was minimal.

**N78-29614# Dynatrend, Inc., Arlington, Va.  
NATIONAL FUEL CELL SEMINAR PROGRAM AND  
ABSTRACTS**

1977 124 p. refs Seminar held at Boston, 21-23 Jun. 1977  
Sponsored by DoE

(CONF-770664-Absts) Avail: NTIS HC A06/MF A01

Abstracts of 40 papers are presented. Topics include fuel  
cell systems, phosphoric acid fuel cells, molten carbonate fuel  
cells, solid fuel and solid electrolyte fuel cells, low temperature  
fuel cells, and fuel utilization. Author (ERA)

A79-14947 \* # Fuel cell on-site integrated energy system  
parametric analysis of a residential complex. S. N. Simons (NASA,  
Lewis Research Center, Cleveland, Ohio). U.S. Department of  
Energy, Fuel Cell Workshop, Sarasota, Fla., Nov. 14-17, 1977, Paper.  
24 p. 7 refs.

The use of phosphoric acid fuel cell powerplant to provide all  
the electricity required by an 81-unit garden apartment complex is  
studied. Byproduct heat is recovered and provides some of the heat  
required by the complex. The onsite integrated energy system  
contains energy conversion equipment including combinations of  
compression and absorption chillers, heat pumps, electric resistance  
heaters, and thermal storage.

77A25875 ISSUE 10 PAGE 1669 CATEGORY 44  
76/00/00 157 PAGES UNCLASSIFIED DOCUMENT

UTTL: Fuel cells --- Book

AUTH: A/MCDUGALL, A. O. PAA: A/(University of Manchester  
Institute of Science and Technology, Manchester,  
England) SAP: \$11.95  
New York, Halsted Press, 1976, 157 p.

MAJS: /\*ENERGY TECHNOLOGY/\*FUEL CELLS

MINS: / CARNOT CYCLE/ ECONOMIC ANALYSIS/ ELECTROCHEMISTRY/  
ELECTROMOTIVE FORCES/ ELECTRON TRANSFER/ HIGH  
TEMPERATURE/ HYDROGEN OXYGEN FUEL CELLS/ LOW  
TEMPERATURE/ MOLTEN SALT ELECTROLYTES/ POLARIZATION  
(CHARGE SEPARATION)/ THERMODYNAMIC EFFICIENCY

ABA: G.R.

ABS: The thermodynamic efficiency of fuel cells is examined  
and relations concerning the electromotive force of  
fuel cells are considered. An investigation is  
conducted regarding the rates of electrode processes,  
taking into account the types of polarization, the  
role of electron transfer, surface chemistry  
reactions, concentration polarization, chain  
polarization, the hydrogen electrode, the oxygen  
electrode, and questions of overall performance.  
Attention is given to low temperature hydrogen-oxygen  
cells, low temperature cells of other types, medium  
temperature cells, high temperature cells, air  
depolarized cells, aspects of fuel cell operation,  
applications of fuel cell systems, fuel cell

economics, and the future of fuel cells.

**77A25875 Fuel cells 1976**  
**CN-142,805, v.1-3**  
**ARMY SCIENCE CONFERENCE PROCEEDINGS. VOLUME I:**  
**PRINCIPAL AUTHORS A THRU G. VOLUME II: PRINCIPAL**  
**AUTHORS H THRU M. VOLUME III: PRINCIPAL AUTHORS**  
**N THRU Z. (Held U.S. Military Academy, West Point,**  
**N.Y., June 22-25, 1976). 1976. 482p. 480p. 426p.**

**Department of the Army**  
**Conference on Army Science**

**Conferences - Army**  
**Conferences - Science**

An Improved Electrolyte for  
Direct Oxidation Fuel Cells

3 345

77A15804 ISSUE 4 PAGE 561 CATEGORY 44 76/10/00  
3 PAGES In GERMAN UNCLASSIFIED DOCUMENT

UTTL: Fuel cells --- electrochemical energy conversion  
AUTH: A/HUENING, R.

Energie, vol. 28, Oct. 1976, p. 296-299. In German.

MAJS: /\*ELECTRIC POWER SUPPLIES/\*ELECTROCHEMISTRY/\*ENERGY  
CONVERSION/\*FUEL CELLS/\*SPACECRAFT POWER SUPPLIES

MINS: / ALKALINE BATTERIES/ ELECTROLYTIC CELLS/ ENERGY  
TECHNOLOGY/ ENVIRONMENT PROTECTION/ HEAT EXCHANGERS/  
HYDROCARBON FUELS/ HYDROGEN-BASED ENERGY/ NATURAL GAS/  
POLLUTION CONTROL/ TECHNOLOGY ASSESSMENT/ TECHNOLOGY  
UTILIZATION

ABA: R.D.V.

ABS: A state-of-the-art survey classifies fuel cells (FC)  
as either low-power application-oriented devices or  
power-generating units, enumerates and describes  
various types of viable and promising FC and their  
applications. Early recognition of the feasibility of  
FC in space applications, and their indispensability  
in long-term space missions (particularly in manned  
flight), are noted. Attention is centered on FC  
burning natural gas as fuel. Components of a FC  
power-generating set are described. Promising use of  
FC in space heating and vehicle propulsion is  
indicated, with auxiliary systems (pumps, heat  
exchangers, water separators) not yet ready to support  
the FC power systems. The need for cheap electrodes,  
FC using air as oxidizer, and elimination of  
polarization at the electrodes is pointed out.

CN-142,805, v.1-3

1976

ARMY SCIENCE CONFERENCE PROCEEDINGS, VOLUME I:  
PRINCIPAL AUTHORS A THRU G. VOLUME II: PRINCIPAL  
AUTHORS H THRU M. VOLUME III: PRINCIPAL AUTHORS  
N THRU Z. (Held U.S. Military Academy, West Point,  
N.Y., June 22-25, 1976). 1976. 482p. 480p. 426p.

Department of the Army  
Conference on Army Science

Conferences - Army  
Conferences - Science

Surface Research for Develop-  
ment of New Electrocatalysts  
for Acid Electrolyte Fuel Cells

2 247

77A15816 ISSUE 4 PAGE 562 CATEGORY 44 76/12/00  
16 PAGES UNCLASSIFIED DOCUMENT

UTTL: Fuel cell assemblies with an acidic electrolyte

AUTH: A/BOEHM, H. PAA: A/(Telefunken AG,  
Forschungsinstitut, Frankfurt am Main, West Germany)  
Journal of Power Sources, vol. 1, Dec. 1976, p.  
177-192.

MAJS: /\*ELECTROCATALYSTS/\*ELECTROLYTIC CELLS/\*FUEL CELLS/\*  
HYDROCARBON FUELS

MINS: / CARBON MONOXIDE/ CATALYTIC ACTIVITY/ DESIGN ANALYSIS  
/ ELECTROLYTES/ ENERGY TECHNOLOGY/ METHYL ALCOHOLS/  
VOLT-AMPERE CHARACTERISTICS

ABA: (Author)

ABS: The application of fuel cells in the lower power range  
up to 10 kW depends on the use of commercially  
available liquid fuels like gasoline, diesel oil or  
methanol. This means a fuel conditioning to produce a  
hydrogen containing crude gas, which can best be  
consumed by a fuel cell with an acidic electrolyte.  
The possibilities for fuel conditioning are described.  
The crude gas can be oxidized at different non-noble  
metal catalysts, e.g., WC, which are not poisoned by  
crude gas components such as CO. This report also  
reviews various cathode catalysts. A conceptual design  
of a battery able to operate in diluted acids at  
higher temperatures is described.

77N22620# ISSUE 13 PAGE 1745 CATEGORY 44 RPT#:  
BNL-21498 CONF-760482-1 CNT#: E(30-1)-16 76/04/00  
37 PAGES UNCLASSIFIED DOCUMENT

UTTL: Hydrogen storage, water electrolysis and fuel cells  
for electric energy storage

AUTH: A/SALZANO, F. J.; B/BRAUN, C.; C/BEAUFRERE, A.;  
D/SRINIVASAN, S.; E/STRICKLAND, G.; F/REILLY, J. J.

CORP: Brookhaven National Lab., Upton, N. Y. AVAIL NTIS  
SEP: HC A03/MF A01

Presented at Symp. on Energy Storage by an  
Electrochem. Method: Some New Methods, Grenoble,  
France, 9 Apr. 1976

MAJS: /\*ELECTROLYSIS/\*ENERGY STORAGE/\*FUEL CELLS/\*HYDROGEN/  
WATER

MINS: / COST ANALYSIS/ ENERGY TECHNOLOGY/ PERFORMANCE TESTS  
ABA: ERA

ABS: The process and physical configuration, performance  
and costs of such a system are presented and  
discussed, as well as the prognosis for eventual  
application in a utility system. The key requirement  
necessary to make hydrogen production attractive for  
utility applications is the flexible and maximum  
utilization of the capital facilities required for  
production, storage, and where applicable, electric  
conversion.

77A28168 ISSUE 11 PAGE 1865 CATEGORY 44  
76/00/00 3 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Hydrocarbon fuel conditioner for a 1.5 kw fuel cell  
power plant  
AUTH: A/CALLAHAN, M. A.; B/HAAS, W. R. PAA: A/(U.S. Army,  
Army Mobility Equipment Research and Development  
Command, Fort Belvoir, Va.); B/(III Research  
Institute, Chicago, Ill.)  
In: Power Sources Symposium, 27th, Atlantic City,  
N.J., June 21-24, 1976, Proceedings. (A77-28126 11-44)  
Red Bank, N.J., PSC Publications Committee, 1976, p.  
180-182.  
MAJS: /\*ELECTRIC POWER PLANTS/\*ENERGY CONVERSION EFFICIENCY  
/\*ENERGY TECHNOLOGY/\*FUEL CELLS/\*HYDROCARBON FUELS/\*  
REACTOR DESIGN  
MINS: / FUEL-AIR RATIO/ HEAT EXCHANGERS/ HYDROGEN/ METHYL  
ALCOHOLS/ OXIDATION RESISTANCE/ PYROLYSIS/ RECYCLING

TJ Energy development II ... c1976. (Card 2)  
153 covering papers presented at the National  
.E4733 Power Engineering Society meetings."  
pt.2 1. Power resources--Congresses. 2.  
Electric power--Congresses. I. IEEE  
Power Engineering Society. IEEE Power  
Generation Committee. Energy Development  
Subcommittee. II. Series.

Inverters for Commercial Fuel Cell Power Generation,  
by G. A. Phillips, J. H. Vogt, and J. W. Walton.....

QD Australian Conference on Electrochemistry,  
551 4th, Flinders University of South Australia,  
.A87 1976.  
1976 Trends in electrochemistry ... c1977.  
(Card 2)  
xi, 408 p. : ill. ; 26 cm.  
Organized by the Electrochemical Division,

*The Development and Practical Application of Fuel Cells . . . 27*  
F.T. BACON

78V20080 1976 ISS: 43 TK2931.6553 1976 0-85626-014-2  
621.359  
AUTH: A/Oniclu, Liviu  
UTTL: Fuel cells.  
Abacus Press, Tunbridge Wells, Kent; 178 p. illus.  
24 cm.  
Translated from Rumanian. Translation of Pile de  
combustie. Includes bibliographies.  
LC: Fuel cells.  
NASA: / AUTOMOBILES/ ELECTRIC GENERATORS/  
ELECTROCHEMISTRY/ ELECTRODES/ FUEL CELLS/ SPACECRAFT  
POWER SUPPLIES  
MAIN-AUTH TRACE-TITL\* CATLG BY-FACILITY  
76/09/30 Publ In UNITED KINGDOM COPYRIGHT AVAIL: /  
LEWIS

TK McDougall, Angus O 1934-  
2931 Fuel cells / Angus McDougall. -- New York  
.M3 : Wiley, c1976.  
xii, 147 p. : ill. ; 24 cm. -- (Energy  
alternatives series)  
"A Halsted Press book."  
Bibliography: p. 140-141.  
Includes index.  
ISBN 0-470-15143-9  
1. Fuel cells. I. Title. II. Series.

78V28002 1976 ISS: 00 TK2931.M3 0-470151-43-9 621.359  
LC-76-15162  
AUTH: A/McDougall, Angus . A/1934-  
UTTL: Fuel cells / by Angus McDougall.  
Wiley, New York : xii, 147 p. : ill. ; 24 cm.  
Energy alternatives series "A Halsted Press book."  
Includes index. Bibliography: p. (140)-141.  
LC: Fuel cells.  
MAIN-AUTH TRACE-SERS-TITL\* CATLG BY-LC

✓ 79N75032\* CATEGORY 44 RPT#: NASA-CR-158262 SAR-17  
CNT#: NGR-10-005-022 74/05/23 73 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Mass-transfer in fuel cells TLSP: Semiannual Report.  
1 Sep. 1973 - 28 Feb. 1974

AUTH: A/WALKER, R. D., JR.

CORP: Florida Univ., Gainesville. CSS: (College of  
Engineering.) AVAIL NTIS

MAJS: /\*FUEL CELLS/\*MASS TRANSFER

MINS: / CATALYSTS/ CONCENTRATION (COMPOSITION)/ INTERFACIAL  
TENSION/ PLATINUM/ POTASSIUM HYDROXIDES/ TEFLON  
(TRADEMARK)/ TEMPERATURE EFFECTS

✓ 78V15516 1963 ISS: 70 TK2920.M5 1963 621.35 LC-  
63-16970

AUTH: A/Mitchell, Will, A/1914 PAT: A/ed.

UTTL: Fuel Cells.

Academic Press, New York, xv, 442 p. illus., port.,  
diagns., tables. 24 cm.

Chemical technology: a series of monographs. 1  
Includes bibliographies.

LC: Fuel cells.

ADDED: Series: Chemical technology, 1

NASA: / CHEMICAL ENERGY/ FUEL CELLS/ TECHNOLOGIES

MAIN-AUTH TRACE- CATLG BY-LC

77/11/28 AVAIL: / FLIGHT

✓ 78V31068 1967 ISS: 00 TK2931.AB7 621.359 LC-66-60090

AUTH: A/Austin, Leonard G.

UTTL: Fuel cells: TLSP: a review of government sponsored  
research, 1950 -1964 (by) L. G. Austin.

National Aeronautics and Space Administration: (for  
sale by the Supt. of Docs., U.S. Govt. Print. Off.,  
Washington) xiii, 439 p. illus. 26 cm.

NASA SP-120 Cover title. "(Prepared) under contract  
NASw-1039." Includes bibliographies.

LC: Fuel cells. Fuel cells -- Bibliography.

ADDED: United States. National Aeronautics and Space  
Administration. United States. National Aeronautics

and Space Administration. NASA Sp-120.

NASA: / ENERGY STORAGE/ ENERGY TECHNOLOGY/ FUEL CELLS/

NASA PROGRAMS/ RESEARCH/ TECHNOLOGY ASSESSMENT/ UNITED  
STATES OF AMERICA

MAIN-AUTH TRACE-SERS-CORP-TITL\* CATLG BY-LC

/ / AVAIL: / JOHNSON

✓ 79V16304 1967 ISS: 95 TK2931.H36 621.359 LC-67-114586  
AUTH: A/Hart, Anthony Bernard; B/Womack, Gerard Joseph.  
PAT: B/joint author.

UTTL: Fuel cells: TLSP: theory and application by A. B.  
Hart and G. J. Womack.  
Chapman & Hall, London, xii, 372 p. illus., tables,  
diagns. 19 cm.

Modern electrical studies Includes bibliographical  
references.

LC: Fuel cells.

NASA: / ELECTRIC CELLS/ ELECTROCHEMISTRY/ ELECTROLYTES  
/ ENERGY STORAGE/ FUEL CELLS/ SOLAR CELLS/ THERMIONIC  
CONVERTERS

JPL: / TK2931.H325

MAIN-AUTH TRACE-AUTH\* CATLG BY-LC

78/12/22 Publ In UNITED KINGDOM AVAIL: / JPL

✓ 77N77168\*# CATEGORY 44 RPT#: NASA-CR-152767  
66/09/15 116 PAGES UNCLASSIFIED DOCUMENT

UTTL: W. H. Podolny Low Temperature Fuel Cell presentation  
to NASA on 15 Sep. 1976

CORP: Pratt and Whitney Aircraft, East Hartford, Conn.  
AVAIL NTIS

Sponsored by NASA

MAJS: /\*FUEL CELLS/\*LOW TEMPERATURE

MINS: / COOLING SYSTEMS/ DESIGN ANALYSIS/ PERFORMANCE/ WATER



## ENERGY STORAGE - THERMAL

BOA10846 ISSUE 1 PAGE 79 CATEGORY 44 79/12/00  
9 PAGES UNCLASSIFIED DOCUMENT

UTTL: Performance of an inexpensive constant flow solar collector/storage system in ground

AUTH: A/SODHA, M. S.; B/SRIVASTAVA, A.; C/TINARI, G. N.; D/KAUSHIK, S. C.; E/MALIK, M. A. S. PAA: D/(Indian Institute of Technology, New Delhi, India); E/(Kuwait Institute of Scientific Research, Safat, Kuwait) International Journal of Energy Research, vol. 3, Oct.-Dec. 1979, p. 379-387.

MAJS: /\*COST REDUCTION/\*HEAT STORAGE/\*SOLAR COLLECTORS/\*SOLAR HEATING/\*THERMODYNAMIC EFFICIENCY/\*UNDERGROUND STORAGE

MINS: / ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY/ GRAPHS (CHARTS)/ MATHEMATICAL MODELS/ PERFORMANCE PREDICTION/ THERMAL INSULATION

ABA: (Author)

ABS: This paper presents an analysis of the performance of an inexpensive constant flow solar collector/storage system, which has been validated by experiments. The system consists of a network of pipes buried in the ground, the top surface of the ground being blackened by black board paint spray and suitably glazed. The heat can be extracted by flow of fluid in the pipes at a constant flow rate. It is seen that for a 7 cm depth of the plane of heat retrieval and 8 l/min flow rate of water, the collection efficiency of the system is 20.0 per cent. The efficiency increases with flow rate and decreases with the depth of the plane of heat retrieval.

PRINT 53/2/1-25 TERMINAL=33

BOVI5265 1979 ISS: 00 TH7413.W54 697.78 LC-79-127974  
AUTH: A/Wilson, Alex T.

UTTL: Thermal storage wall design manual / by Alex Wilson. New Mexico Solar Energy Association, Santa Fe : 40 p. : ill. : 28 cm.

\$4.00 Bibliography: p. 38-40.

LC: Solar heating -- Passive systems. Heat storage devices -- Design and construction.

MAIN-AUTH TRACE-TITL\* CATLG BY-LC

79N29636# ISSUE 20 PAGE 2695 CATEGORY 44 RPT#:  
ANL-79-15 CNT#: W-31-109-ENG-38 79/02/00 283  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Design and Installation manual for thermal energy storage

AUTH: A/COLE, R. L.; B/NIELD, K. J.; C/RHODE, R. R.; D/WOLOSEWICZ, R. M. PAT: A/ed.; B/ed.; C/ed.; D/ed.

CORP: Argonne National Lab., Ill. CSS: (Solar Energy Group.) AVAIL.NTIS SAP: HC A13/NF A01

MAJS: /\*ENERGY STORAGE/\*SOLAR ENERGY CONVERSION/\*STRUCTURAL DESIGN/\*SYSTEMS ENGINEERING/\*THERMAL ENERGY

MINS: / COST ESTIMATES/ INSTALLATION MANUALS/ INSULATION/ MAINTENANCE/ POSITION (LOCATION)

ABA: DOE

ABS: Information on the design and installation of thermal energy storage in solar heating systems is provided. The manual presented includes sizing storage, choosing a location for the storage device, and insulation requirements. Both air-based and liquid-based systems are covered with topics on designing rock beds, tank types, pump and fan selection, installation, costs, and operation and maintenance. Topics relevant to heating domestic water include safety, single- and dual-tank systems, domestic water heating with air- and liquid-based space heating system, and stand-alone domestic hot water systems.

BON71074# CATEGORY 44 RPT#: SAN-1101/PA2-6

ATR-76(7523-11)-6 CNT#: EY-76-C-03-1101-002

76/08/00 55 PAGES UNCLASSIFIED DOCUMENT

UTTL: Highlights report: Solar thermal Conversion Program, Central Power Projects

AUTH: A/CONNOR, T. J.; B/MATHUR, P. P.

CORP: Aerospace Corp., El Segundo, Calif. CSS: (Energy and Transportation Div.) AVAIL.NTIS

Semiannual Review held at Washington D.C., 3 Jun. 1976

MAJS: /\*ELECTRIC GENERATORS/\*ENERGY TECHNOLOGY/\*HEAT STORAGE /\*SOLAR ENERGY

MINS: / BOILERS/ ECONOMIC FACTORS/ ENVIRONMENT EFFECTS/ HELIOSTATS/ SYSTEMS ENGINEERING

BOA12427 ISSUE 2 PAGE 245 CATEGORY 44 CNT#: E(11-1)-2588 79/08/00 20 PAGES UNCLASSIFIED DOCUMENT

UTTL: On the performance of air-based solar heating systems utilizing phase-change energy storage

AUTH: A/JURINAK, J. J.; B/ABDEL-KHALIK, S. I. PAA: B/(Wisconsin, University, Madison, Wisc.) Energy (UK), vol. 4, Aug. 1979, p. 503-522.

MAJS: /\*HEAT STORAGE/\*PERFORMANCE TESTS/\*PHASE TRANSFORMATIONS/\*PHYSICAL PROPERTIES/\*SOLAR ENERGY ABSORBERS/\*SOLAR HEATING

MINS: / ENERGY TECHNOLOGY/ FEASIBILITY/ MELTING POINTS/ SOLAR COLLECTORS

ABA: (Author)

ABS: Simulation techniques are used to examine the performance of air-based solar heating systems utilizing phase change energy storage (PCES). The effects of storage size, melting temperature, and latent heat on the thermal performance of the system are quantified for various load characteristics, collector types, and control strategies. The effect of semi-congruent melting of the phase-change material (PCM) on system performance is also examined. Based on these simulations, (1) optimum physical properties of the PCM have been identified, (2) an empirical method for sizing PCES units has been developed, (3) a system-oriented figure of merit for comparing different PCMs has been established, and (4) the economic gains associated with the storage volume reductions achieved with PCES, vis-a-vis sensible heat storage in rock beds, have been quantified.

# AN ASSESSMENT OF THERMAL ENERGY STORAGE IN CONJUNCTION WITH HEAT PUMPS FOR RESIDENTIAL HEATING AND COOLING. M. B. Packer and L. R. Glicksman.

Energy, vol 40, no 3, June 1979, p. 393-399.

Abstract--The potential of thermal energy storage together with heat pumps to lower peak daytime residential electrical consumption and exploit off-peak rate reductions is examined. A computer simulation using New York City weather demonstrates that this approach, although technically successful, is economically infeasible for the foreseeable future.

BOA17582 ISSUE 5 PAGE 823 CATEGORY 44 79/00/00 32 PAGES UNCLASSIFIED DOCUMENT

UTTL: Solar energy storage by metal hydride

AUTH: A/ONO, S.; B/YAMAGUCHI, M.; C/OKITA, T. PAA: A/(National Chemical Laboratory for Industry, Tokyo, Japan); C/(Yokohama National University, Yokohama, Japan)

In: Solar-hydrogen energy systems. (ABO-17573 05-44)

Oxford and New York, Pergamon Press, 1979, p. 193-224.

MAJS: /\*HEAT STORAGE/\*HYDROGEN PRODUCTION/\*METAL HYDRIDES/\*METAL-GAS SYSTEMS/\*SOLAR ENERGY CONVERSION

MINS: / ENERGY CONVERSION EFFICIENCY/ ENERGY TECHNOLOGY/ THERMOCHEMISTRY

ABA: A.L.W.

ABS: Metal hydride systems for long-term solar thermal energy storage are examined. Various materials for solar heat storage for architectural applications are reviewed, including water, pebble beds, insulators such as rock wool, glass wool and synthetic resins, molten salts and reaction heat storage systems, of which the metal hydride system is considered the most effective. The thermodynamics of metal hydride systems for hydrogen or heat storage are discussed, and the characteristics of some representative systems, namely iron-titanium hydrides, magnesium-nickel hydrides and lanthanum-nickel hydrides, are considered. Results of performance tests of the endothermic and exothermic processes of an iron-titanium system are reported and the HYCSOS hydride conversion and storage system, which employs two types of hydrides, is presented. An ideal heat engine based on the metal hydriding reaction is examined theoretically and a promising prototype chemical engine based on LaNi5H6 is described.

# SOLAR ENERGY STORAGE AS HYDROGEN AND BROMINE FROM HYDROGEN BROMIDE, by E. A. Fletcher. Energy, vol. 4, no. 1, Feb, 1979, p.61-67.

Abstract--The use of hydrogen bromide as the working fluid for a one-step thermochemical solar energy storage device is considered. When dissociation of Br<sub>2</sub> into Br at moderately high temperatures is taken into account, the system becomes one in which high-temperature separation of hydrogen from bromine in one step appears attractive.

✓ BON13593# ISSUE 6 PAGE 761 CATEGORY 44 RPT#:  
SERI/PR-54-164 CNT# 16-77-C-01-4042 79/07/00 120  
PAGES UNCLASSIFIED DOCUMENT

UTTL: Low temperature thermal energy storage: A  
state-of-the-art survey

AUTH: A/BAYLIN, F.

CORP: Midwest Research Inst., Golden, Colo. AVAIL NTIS  
SAP: HC A06/MF A01

MAJS: /ENERGY TECHNOLOGY/HEAT STORAGE/LOW TEMPERATURE/  
SPACE HEATING (BUILDINGS)/TECHNOLOGY ASSESSMENT

MINS: /CHEMICAL REACTIONS/ COOLING/ MARKET RESEARCH/ PHASE  
TRANSFORMATIONS/ SOLAR ENERGY ABSORBERS/  
THERMOCHEMISTRY

ABA: DOE

ABS: The preliminary version of an analysis of activities  
in research, development, and demonstration of low  
temperature thermal energy storage (TES) technologies  
having applications in renewable energy systems is  
presented. Three major categories of thermal storage  
devices are considered: sensible heat; phase change  
materials; and reversible thermochemical reactions.  
Both short-term and annual thermal energy storage  
technologies based on principles of sensible heat are  
discussed. Storage media considered are water, earth,  
and rocks. Annual storage technologies include solar  
ponds, aquifers, and large tanks or beds of water,  
earth, or rocks. All program processes from basic  
research through commercialization efforts are  
investigated. Nongovernment-funded industrial programs  
and foreign efforts are outlined as well. Data  
describing low temperature TES activities are  
presented also as project descriptions.

**N80-15607#** Sandia Labs., Albuquerque, N Mex. Exploratory  
Batteries Div. and Photometrics and Optical Development Div.  
**THERMAL MODEL OF A THERMAL BATTERY**  
D M Bush and R L Hughes Jul. 1979 48 p refs

(Contract EY-76-C-04-0789)  
(SAND-79-0834) Avail: NTIS HC A03/MF A01

A thermal model was developed to predict the effect of  
design changes, such as an increase in insulation thickness, on  
the temperature-time profile of the battery. The model is based  
on a quarter section of the battery, which is divided into a  
10 x 20 grid consisting of 200 nodes. A method of calculating  
an effective conductivity/distance term between nodes negated  
the need for special boundary temperature calculations at material  
interfaces. A separate routine was used to account for the heat  
of fusion released by the buffer pellets. Actual design changes  
selected to check the model were internal heat generation, removal  
of stack end plates, new electrochemical system, increased side  
insulation, and internal electric heater. Results of model runs  
reflecting these changes are compared with temperature-time  
histories recorded from battery tests, and a close correlation is  
obtained in each case. DOE

✓ BOA14667 ISSUE 3 PAGE 420 CATEGORY 44 CNT#:  
NSF ENG-77-21626 79/00/00 10 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Heat transfer to a melting solid with application to  
thermal energy storage systems

AUTH: A/GOLDSTEIN, R. J.; B/RANSEY, J. W. PAA:  
B/(Minnesota, University, Minneapolis, Minn.)

In: Studies in heat transfer: A Festschrift for E. R.  
G. Eckert. (ABO-14655 03-34) Washington, Hemisphere  
Publishing Corp.; New York, McGraw-Hill Book Co.,  
1979. p. 199-208.

MAJS: /ENERGY STORAGE/HEAT TRANSFER/LIQUID-SOLID  
INTERFACES/MELTING/NAPHTHALENE/THERMAL ENERGY

MINS: /HEAT FLUX/ HEAT TRANSFER COEFFICIENTS/ TEMPERATURE  
DISTRIBUTION/ TIME DEPENDENCE/ WALL TEMPERATURE

ABA: V.T.

ABS: The shape of a liquid-solid interface and the local  
heat transfer rate at this interface are studied. The  
experiments are performed with naphthalene in an  
apparatus that is designed to permit continuous  
observation of the melting process. In addition, the  
heater contains thermocouples to evaluate the  
time-varying heater wall temperatures and heat  
transfer coefficients. Photographs of the molten  
region are used to evaluate the local progression of  
the solid-liquid interface and thus the local heat

transfer rates at the interface. It is noted that for  
a considerable period of time the total volume of the  
melted region can be closely obtained from the total  
heat flow and the density and latent heat of the  
solid. The actual shape of the molten region can vary  
considerably depending on the conditions as a plume  
begins to develop.

**N79-29636#** Argonne National Lab., Ill. Solar Energy Group.  
**DESIGN AND INSTALLATION MANUAL FOR THERMAL  
ENERGY STORAGE**

Roger L. Cole, ed. Kenneth J. Nield, ed. Raymond R. Rhode,  
ed. and Ronald M. Wolosewicz, ed. Feb. 1979 283 p refs  
(Contract W-31-109-eng 38)

(ANL-79-15) Avail: NTIS HC A13/MF A01

Information on the design and installation of thermal energy  
storage in solar heating systems is provided. The manual presented  
includes sizing storage, choosing a location for the storage device,  
and insulation requirements. Both air-based and liquid-based  
systems are covered with topics on designing rock beds, tank  
types, pump and fan selection, installation, costs, and operation  
and maintenance. Topics relevant to heating domestic water  
include safety, single- and dual-tank systems, domestic water  
heating with air- and liquid-based space heating system, and  
stand-alone domestic hot water systems. DOE

Design of Residential Buildings Utilizing Natural Thermal Storage. Final Report, by D. Lewis, C. Michal & P. Pietz

Dept. of Energy Document DOE/TIC-10143, June 1979  
Contract no. EY-76-C-02-0016

This study investigates the premise that intelligent use of natural thermal storage (NTS) materials in buildings can lower heating and cooling bills and reduce the national consumption of depletable energy resources. The study focuses on market-competitive residential construction in the northeast and north central United States and on NTS systems based on heat storage materials currently available.

ENERGY STORAGE EFFICIENCY FOR THE AMMONIA/HYDROGEN-NITROGEN THERMOCHEMICAL ENERGY TRANSFER SYSTEM, by  
O. M. Williams and P. O. Carden.  
Energy Research, vol. 3, no. 1 Jan/Mar. 1979, p.29-41.

Energy storage efficiency is calculated for the solar thermochemical energy transfer system based on ammonia/hydrogen-nitrogen. The calculation for this system involves generation of thermodynamic data not available in the literature by a method in which use is made of the available phase equilibrium measurements together with application of the criterion that the correct value of separation work for a two-phase mixture must be generated internally by degradation of mixing heat. Energy storage efficiencies for ammonia/hydrogen-nitrogen are derived from the generated thermodynamic data and are shown to increase towards unity as the endothermic reaction approaches completion, with efficiencies greater than 0.90 being obtained for reaction extents exceeding 0.60. The validity of the analysis has been tested successfully by comparison between the thermodynamic predictions and experimental data in the form of measurements of the waste heat rejected from a counterflow heat exchanger operated with liquid ammonia feed and ammonia/hydrogen-nitrogen output.

A79-31000 Thermal energy storage (Le stockage thermique de l'énergie). M. Coeytaux (Société Caliqua, Paris, France). (Société Française des Mécaniciens, Conférence, Paris, France, Dec. 6, 1977.) *Revue Française de Mécanique*, no. 66, 1978, p. 17-19. In French.

The range of materials that can be used for solar energy storage is very large, and the material to be selected depends on the temperature level and type of storage planned. For storage of sensible heat there are available pressurized water, organic fluids, fused salts, liquid metals, and refractory solids. For storage of latent heat there are nitrates, carbonates, sulfates, chlorides, and fluorides.

P.T.H.

A79-37879 Thermal energy storage using hot liquids. G. E. Clewer, A. Spurr (Central Electricity Generating Board, Marchwood Engineering Laboratories, Marchwood, Surrey, England), and B. J. Davidson (Central Electricity Generating Board, Research Laboratories, Leatherhead, Surrey, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. (A79-37842 15-44) London, Institution of Electrical Engineers, 1979, p. 211-215. 16 refs.

Systems are proposed involving the storage under pressure of boiler feedwater or saturated water; a further option is transfer of heat to an oil store at atmospheric pressure. High stored energy/unit volume appears possible with feedwater storage but a high storage pressure is necessary in order to achieve a worthwhile power output gain. The use of oil as a storage medium may reduce storage costs to values comparable with high pressure underground stores. Saturated water storage using steam ahead of the main turbine control is thermodynamically less efficient than using turbine extraction steam but avoids the 'charging' mode problems. B.J.

33069 (ANL-79-15) Design and installation manual for thermal energy storage. Cole, R.L.; Nield, K.J.; Rohde, R.R.; Wolosewicz, R.M. (eds.). (Argonne National Lab., IL (USA)). Feb 1979. Contract W-31-109-ENG-38. 283p. Doc. NTIS, PC A13/MF A01.

The purpose for this manual is to provide information on the design and installation of thermal energy storage in solar heating systems. It is intended for contractors, installers, solar system designers, engineers, architects, and manufacturers who intend to enter the solar energy business. The reader should have general knowledge of how solar heating systems operate and knowledge of construction methods and building codes. Knowledge of solar analysis methods such as f-chart, SOLCOST, DOE-1, or TRNSYS would be helpful. The information contained in the manual includes sizing storage, choosing a location for the storage device, and insulation requirements. Both air-based and liquid-based systems are covered with topics on designing rock beds, tank types, pump and fan selection, installation, costs, and operation and maintenance. Topics relevant to heating domestic water include safety, single- and dual-tank systems, domestic water heating with air- and liquid-based space heating system, and stand-alone domestic hot water systems. Several appendices present common problems with storage systems and their solutions, heat transfer fluid properties, heat exchanger sizing, and sample specifications for heat exchangers, wooden rock bins, steel tanks, concrete tanks, and fiberglass-reinforced plastic tanks.



79N32682# ISSUE 23 PAGE 3109 CATEGORY 44 RPI#:  
COO-4523-1 CNT#: EG-77-S-02-4523 N68305-76-0036  
78/06/00 64 PAGES UNCLASSIFIED DOCUMENT

UTTL: Stratified thermal storage in residential solar energy applications

AUTH: A/SHARP, K.; B/LOHRKE, R. I.

CORP: Colorado State Univ., Fort Collins, CSS: (Solar Energy Applications Lab.) AVAIL: NTIS SAP: HC A04/MF A01

Washington DOE

MAJS: /\*ENERGY POLICY/\*HEAT STORAGE/\*SOLAR ENERGY/\*

STRATIFICATION/\*SYSTEMS ANALYSIS/\*TECHNOLOGY UTILIZATION

MINS: / AIR CONDITIONING/ COMPUTERIZED SIMULATION/ DESIGN ANALYSIS/ ENERGY STORAGE/ SPACE HEATING (BUILDINGS)/ STORAGE TANKS/ THERMAL ENERGY/ WATER HEATING

ABA: DOE

ABS: The benefits of thermal stratification in sensible heat storage were investigated for several residential solar applications. The operation of space heating, air conditioning and water heating systems with water storage was simulated on a computer. The performance of comparable systems with mixed and stratified storage was determined in terms of the fraction of the total load supplied by solar energy. The effects of design parameters such as collector efficiency, storage volume, tank geometry, etc., on the relative advantage of stratified over well-mixed storage were assessed.

**N80-10622#** General Electric Co., Schenectady, N. Y.  
**CONCEPTUAL DESIGN OF THERMAL ENERGY STORAGE SYSTEMS FOR NEAR-TERM ELECTRIC UTILITY APPLICATIONS. VOLUME 2: APPENDICES, SCREENING OF CONCEPTS**

W. Hausz, B. J. Berkowitz, and R. C. Hare Apr. 1979 151 p refs

(Contract EC-77-A-31-1034; EPRI Proj. 1082-1)

(NASA CR-15941); EPRI-EM-1037-Vol-2) Avail: NTIS HC A08/MF A01

Volume two contains three appendices entitled: (1) Bibliography and Cross References; (2) Taxonomy: Proponents and Sources; and (3) Concept Definitions. DCE

79A42978 ISSUE 18 PAGE 3476 CATEGORY 44  
78/00/00 6 PAGES In FRENCH UNCLASSIFIED DOCUMENT

UTTL: The characteristics of storage of thermal energy by latent heat of fusion

AUTH: A/DESAULIY, M.; B/HUEIZ, J. PAA: B/(CNRS, Groupe de Recherches Thermiques, Chateauf-Malabry, Hauts-de-Seine, France)

In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers, Volume 4. (A79-42973 1B-34) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 173-178. In French.

MAJS: /\*FUSION (MELTING)/\*HEAT STORAGE/\*HEAT TRANSFER/\*MOLTEN SALTS/\*NUMERICAL ANALYSIS

MINS: / GRAPHS (CHARTS)/ HIGH TEMPERATURE/ LIQUEFACTION

ABA: C.K.D.

ABS: The storage of thermal energy by melted salts is considered. The storage unit is assumed to be monodimensional with tubular partitions separating the heat carrier from the material undergoing fusion and liquefaction. The charge and discharge processes are investigated for both the case in which the heat carrier is inside and the case in which it is on the outside of the tube and for temperatures ranging from 700 to 1000 K. The initial approach assumes that energy released by solidification is immediately available to the heat carrier. Subsequently, heat conduction in the solid layer which has been formed is taken into account. Results indicate that heat storage at the exterior of the tube is preferable to the opposite arrangement.

**N80-12588#** Oak Ridge National Lab., Tenn. Engineering Technology Div

**LOW-TEMPERATURE THERMAL ENERGY STORAGE PROGRAM ANNUAL OPERATING PLAN**

H. W. Hoffman and D. M. Eissenberg Jan. 1979 130 p

(Contract W-7405-eng-26)

(ORNL/TM-6605) Avail: NTIS HC A07/MF A01

The LTES program operating plans for FY 1978 are described in terms of general program objectives and the technical activities being implemented to achieve these objectives. The program structure provides emphasis on seasonal thermal storage, daily/short-term thermal storage, and waste heat recovery and reuse. A work breakdown structure organizes the efforts being carried out in-house or through subcontract within each thrust area. Fiscal data are summarized with respect to thrust area, individual efforts, and funding source. DOE

79A16459# ISSUE 4 PAGE 652 CATEGORY 44

78/00/00 18 PAGES UNCLASSIFIED DOCUMENT

UTTL: Thermal storage of solar energy

AUTH: A/KALAC, S.; B/YENER, Y. PAA: B/(Middle East Technical University, Ankara, Turkey)

In: International Symposium-Workshop on Solar Energy, Cairo, Egypt, June 16-22, 1978. Symposium Lectures. (A79-16451 04-44) Coral Gables, Fla.: University of Miami, 1978. p. 159-176.

MAJS: /\*ENERGY STORAGE/\*HEAT STORAGE/\*SOLAR ENERGY/\*SYSTEM EFFECTIVENESS

MINS: / CHEMICAL REACTORS/ CLEAN ENERGY/ ENERGY TECHNOLOGY/ PHASE TRANSFORMATIONS/ WATER

ABA: B.J.

ABS: Two systems for solar heat storage for space heating applications are characterized: (1) sensible-heat storage systems, which can be of the water storage or packed-bed storage type; and (2) phase-change storage systems. Chemical techniques for solar heat storage are also reviewed. These various systems are compared in terms of performance and cost.

79N30801\*# ISSUE 21 PAGE 2849 CATEGORY 44

RPT#: NASA-CR-159398 CONS-5082-1 CNT#: EC-77-A-31-1034 EC-77-C-01-5082 78/09/00 244 PAGES UNCLASSIFIED DOCUMENT

UTTL: Applications of thermal energy storage to process heat storage and recovery in the paper and pulp industry  
TLSP: Final Report, Sep. 1977 - May 1978

AUTH: A/CARR, J. H.; B/HURLEY, P. J.; C/MARTIN, P. J.  
CORP: Boeing Engineering and Construction, Seattle, Wash.  
AVAIL NTIS SAP: HC A11/MF A01  
Sponsored by NASA

MAJS: /\*ENERGY STORAGE/\*HEAT STORAGE/\*HEAT TRANSFER/\* INDUSTRIAL ENERGY/\*THERMAL ENERGY/\*UTILIZATION

MINS: / ACCUMULATORS/ BOILERS/ INDUSTRIES/ RECLAMATION/ WASTE ENERGY UTILIZATION

ABA: DOE

ABS: Applications of Thermal Energy Storage (TES) in a paper and pulp mill power house were studied as one approach to the transfer of steam production from fossil fuel boilers to waste fuel of (hog fuel) boilers. Data from specific mills were analyzed, and various TES concepts evaluated for application in the process steam supply system. Constant pressure and variable pressure steam accumulators were found to be the most attractive storage concepts for this application.

78N26329# ISSUE 17 PAGE 2242 CATEGORY 44 RPT#:

GMR-2690-SECT-7.103 76/04/00 23 PAGES

UNCLASSIFIED DOCUMENT

UTTL: Thermal energy storage for road vehicle propulsion

AUTH: A/PERCIVAL, W. H.

CORP: General Motors Research Labs., Warren, Mich.

AVAIL NTIS SAP: HC A11/MF A01

In its A Collection of Stirling Eng. Rept. from Gen. Motors' Res., 1958 to 1970. Pt. 7: Thermal Energy Storage and Publ. Lists. 7.1 Thermal Energy Storage. 7.2 List of Gen. Motors Stirling Eng. Publ. 23 p (SEE N78-26326 17-31)

MAJS: /\*ENERGY STORAGE/\*SURFACE VEHICLES/\*THERMAL ENERGY

MINS: / ENGINE DESIGN/ HEAT TRANSFER/ LITHIUM FLUORIDES/ STIRLING CYCLE

ABA: Author

ABS: Small systems are shown to be at a considerable disadvantage compared to large systems. The problem of heat loss and insulation is described, and methods of transferring heat from the storage unit to the engine are explained. Various properties and heat capacity of 10 solid heat storage substances are compared to lithium fluoride. Three compounds are then compared for a specific application to a small vehicle, and boron carbide is recommended. A small two passenger vehicle is briefly described, along with some theoretical performance. A particular Stirling engine and its ancillaries are explained, along with several transmission types. The weight of the power system is estimated and compared to an electric battery system.

78V40621 1978 ISS: 00 TH7413.D43 0-891680-05-5 697.78 LC-78-15697

AUTH: A/Dean, Thomas, Scott.

UTTL: Thermal storage / Thomas Scott Deam.

Franklin Institute Press, Philadelphia : 51 p. : ill. ; 23 cm.

Solar energy series \$6.50 Includes bibliographical references.

LC: Solar heating. Heat storage devices -- Design and construction.

NASA: / CONSTRUCTION/ ENERGY STORAGE/ HEAT STORAGE/ SOLAR ENERGY/ SOLAR HEATING/ STORAGE TANKS/ STRUCTURAL DESIGN

JPL: / TH7413.D281

MAIN-AUTH TRACE-SERS-TITL\* CATLG BY-LC

/ / COPYRIGHT AVAIL: / JOHNSON/ JPL/ LANGLEY/ LEWIS

# EXPERIMENTS ON THE ROLE OF NATURAL CONVECTION IN THE MELTING OF SOLIDS.

F. M. Sparrow, R. R. Schmidt & J. W. Ramsey  
Transactions of the ASME; Journal of Heat Transfer,  
Vol. 100, No. 1, February 1978, p. 11-16

*Experiments are performed whose results convey strong evidence of the dominant role played by natural convection in the melting of a solid due to an embedded heat source. The research encompassed both melting experiments and supplementary natural convection experiments, with a horizontal cylinder as the heat source. For the melting studies, the cylinder was embedded in a solid at its fusion temperature, whereas in the natural convection tests it was situated in the liquid phase of the same solid. A special feature of the experiments was the use of a grid of approximately 100 thermocouples to sense thermal events within the phase change medium. The time history of the heat transfer coefficients for melting was characterized by an initial sharp decrease followed by the attainment of a minimum and then a rise which ultimately led to a steady value. This is in sharp contrast to the monotonic decrease that is predicted by a pure conduction model. The steady state values were found to differ only slightly from those measured for pure natural convection. This finding enables melting coefficients to be taken from results for natural convection. The positions of the solid-liquid interface at successive times during the melting process also demonstrated the strong influence of natural convection. These interfaces showed that melting primarily occurred above the cylinder. In contrast, the interfaces given by the conduction model are concentric circles centered about the cylinder.*

78A46525 ISSUE 20 PAGE 3667 CATEGORY 44  
78/00/00 58 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Thermal storage --- Book  
AUTH: A/DEAN, T. S. PAA: A/(Kansas. University. Lawrence.  
Kan.) SAP: \$6.50  
Philadelphia, Pa., Franklin Institute Press, 1978. 58  
p.

MAJS: /DOMESTIC ENERGY/ENERGY STORAGE/SOLAR HEATING/  
THERMAL ENERGY

MINS: / BLOCK DIAGRAMS/ CLEAN ENERGY/ CONDUCTIVE HEAT  
TRANSFER/ ENERGY TECHNOLOGY/ HEATING EQUIPMENT/ SOLAR  
HOUSES/ SOLAR PONDS (HEAT STORAGE)/ STORAGE TANKS/  
SYSTEMS ENGINEERING/ WATER

ABA: D.M.W.

ABS: The problems of thermal energy storage are examined in  
terms of the design characteristics of systems to be  
used with solar heating units. Among the systems  
considered are: active and passive heating, water,  
rock, and hybrid systems, and specially designed  
houses. The physics of heat storage are discussed with  
reference to heat conduction and loss in storage, and  
in terms of storage materials and the size and shape  
of storage containers.

# COMPARISONS OF DEEP WELL AND INSULATED SHALLOW EARTH STORAGE OF SOLAR HEAT

R.L. Nichols  
Solar Ener., v.20, no.2, 1978, p.127-137.

Solar thermal energy for heating and cooling buildings  
has been stored by: (a) insulated water tanks or rock  
bins; (b) water ponds; (c) salt solutions having fusion  
temperatures which permit storage of latent heat in ad-  
dition to specific heat; (d) earth storage by pumping  
heated air or water through closed tubing systems; and  
(e) earth storage by pumping heated water to and from  
wells[1-5].

An advantage of the various earth heat storage  
methods is the use of a material already existing at the  
building site, usually in sufficient quantity to store heat  
for several months rather than just a few days, and  
thereby permit an expensive solar collector to operate  
closer to peak capacity throughout all seasons of the  
year. Major disadvantages include the cost of heat loss,  
or of insulating to reduce heat loss. This paper describes  
four of the possible earth heat storage methods and  
compares their costs by a hypothetical example.

79V10807 1978 ISS: 00 TH7413.T43 621.471 LC-78-68099

AUTH: A/Kreith, Frank.

JTTL: Thermal storage and heat transfer in solar energy  
systems : TLSP: presented at the winter annual meeting  
of the American Society of Mechanical Engineers, San  
Francisco, California, December 10-15, 1978 /  
sponsored by the Solar Energy Division, ASME, the Heat  
Transfer Division, ASME ; edited by Frank Kreith ...  
(et al.).

ASME, New York : v. 79 p. : ill. : 29 cm.

Includes bibliographical references.

LC: Solar heating -- Congresses. Heat storage. Heat --  
Transmission.

ADDED: American Society of Mechanical Engineers. Solar  
Energy Division. American Society of Mechanical  
Engineers. Heat Transfer Division.

NASA: / CONFERENCES/ ENERGY TECHNOLOGY/ HEAT STORAGE/  
HEAT TRANSFER/ SOLAR HEATING/ THERMOHYDRAULICS

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TRANSIENT BEHAVIOR OF A SOLID SENSIBLE HEAT THERMAL STORAGE EXCHANGER.

J. Szego & F. W. Schmidt

Transactions of the ASME; Journal of Heat Transfer, Vol. 100, No. 1, February 1978, p. 148-154

*The transient response characteristics of a solid sensible heat storage exchanger which interacts with two energy transporting fluids are presented. The storage unit is composed of a series of large aspect ratio rectangular channels for the fluids, separated by slabs of the heat storage material. The hot and cold fluids flow in counter current fashion, in alternate channels so that each slab of storage material is in contact with both fluids. The entire system is considered to be initially in equilibrium at a uniform temperature, a step change in the inlet temperature of one of the fluids is imposed, and the thermal response of the unit is predicted until steady state conditions are reached. The response of the storage exchanger to an arbitrary time variation of one of the fluids' inlet temperature may be obtained using superposition.*

TH Dean, Thomas S.

7413 Thermal storage / T. S. Dean. — Philadelphia : Franklin Institute Press, 1978.  
.D43 61 p. : ill. — (Solar energy series)  
Includes bibliographical references.  
ISBN 0-891680-05-5

The problems of thermal storage are examined in terms of the design characteristics of systems to be used with solar heating units (active and passive heating, water, rock, and hybrid systems, and specially designed houses).

TJ Turner, Robert H.

260 High temperature thermal energy storage :  
.T76 including a discussion of TES integrated into power plants / Robert H. Turner. — Philadelphia : Franklin Institute Press, 1978.

101 p. : ill. — (Solar energy series)  
ISBN 0-89168-000-4

1. Energy storage. 2. Heat storage.  
I. Title. II. Series.

MEASUREMENTS OF THE BEHAVIOUR OF ADSORBENT ENERGY STORAGE BEDS.

T.L. Pryor and D.J. Close

Solar Ener., v.20,no.2, 1978, p.151-155.

This paper describes both the experimental apparatus and the three main experiments that were conducted. From the results, it is concluded that while large inaccuracies occur in trying to model a step-change process, satisfactory accuracy is obtained for the case where charge and discharge periods are alternated and the inlet temperatures determined by a random number sequence. These conditions are similar to the conditions found in a solar system.

Thermal Energy Storage.

P. G. Grodzka, and E. A. Picklesimer.

Lockheed Missiles and Space Co., Huntsville, Ala.  
Research and Engineering Center. 10 Feb 78, 28p  
NASA-CR-150563, LMSC-HREC-TR-D568188  
N78-18520/4WE Price code: PC A03/MF A01

The general scope of study on thermal energy storage development includes: (1) survey and review possible concepts for storing thermal energy; (2) evaluate the potentials of the surveyed concepts for practical applications in the low and high temperature ranges for thermal control and storage, with particular emphasis on the low temperature range, and designate the most promising concepts; and (3) determine the nature of further studies required to expeditiously convert the most promising concept(s) to practical applications. Cryogenic temperature control by means of energy storage materials was also included.

ENERGY STORAGE USING THE REVERSIBLE OXIDATION OF BARIUM OXIDE, by R. G. Bowrey and J. Jutsen.  
Solar Energy, vol. 21, no. 6, 1978, p.523-525.

This article describes a series of experiments which were performed to establish the practical feasibility of the BaO/BaO<sub>2</sub> system.



ET Greater Los Angeles Area Energy Symposium, Los Angeles, 1978.

.G74 Greater Los Angeles Area Energy Symposium  
1978 : Tuesday, May 23, 1978 ... Los Angeles,

• Thermal Energy Storage Systems for  
Electrical Load Leveling in Commer-  
cial Buildings — Kenneth L. Heitner  
Pamela S. Moritz, TRW, Inc.

Los Angeles  
ntists under  
as Section of

Thermal energy storage systems for utility load leveling in commercial buildings are discussed. Basic cost and performance information is provided, along with an economic evaluation. The cost effectiveness of these systems for summer peaking utility areas is demonstrated.

Council of Engineers Scientists  
proceedings ser. ; v. 4)

A PARAMETRIC STUDY OF HOT WATER STORAGE FOR  
PEAK POWER GENERATION.

K. W. Li

Journal of Engineering Power, Vol. 100, No. 2, April 1978, p. 229-234.

This paper is intended to present a parametric study of a steam-turbine power plant with hot-water storage. The study will identify the parameters affecting the plant performance and its economic acceptance. Also, fuel cost and storage size are estimated for peak power generation.

A PRESSURIZED - LIQUID CONCEPT FOR SOLAR -  
THERMAL ENERGY STORAGE.

Mostafa E. Talaat

Journal of Energy, Vol. 2, No. 3, May/June  
1978, p. 136-141.

A pressurized-liquid concept for solar-thermal energy storage is presented for continuous operation of power systems. The thermal performance of modular systems is analyzed to assess the feasibility of designing and operating pressurized-liquid solar-thermal energy storage systems to continuously supply thermal power inputs to energy conversion systems. Temperatures would vary cyclically between upper and lower values within levels sufficiently high to attain good efficiencies of the overall solar-thermal power system. This feasibility is demonstrated by choosing, for example, pressurized water at 170.1 atmospheres as the working medium and designing a pressure vessel to operate with a parabolic cylindrical solar collector in the solar radiation prevailing during winter in typical semitropical regions.

REVOLVING BARREL

Richard Stephler

Popular Science, vol. 212, no. 5, May 1978, p. 91

A slowly turning cylinder  
filled with slush could  
keep you warm when the  
sun's not shining

PROPERTIES OPTIMIZATION FOR PHASE-CHANGE ENERGY  
STORAGE IN AIR-BASED SOLAR HEATING SYSTEMS,

by J. J. Jurinak and S. I. Abdel-Khalik.

Solar Energy, vol. 21, no. 5, 1978, p.377-383.

Abstract—A parametric study has been conducted to determine the optimum physical properties of phase-change energy storage materials for solar air-heating systems. Simulation techniques are used to determine the system performance over the entire heating season. Variations of the solar fraction of the load with melting temperature, latent heat, load characteristics, and control strategy have been determined. Air-heating systems with a wide range of hot water and space heating loads have been examined. The effect of semicongruent melting of the phase change material on system performance has also been investigated.

N80-10627/ Oak Ridge National Lab., Tenn.  
SURVEY OF SOLAR THERMAL ENERGY STORAGE  
SUBSYSTEMS FOR THERMAL/ELECTRIC APPLICATIONS

C. L. Segesser Aug 1978 101 p refs

(Contract W-7405-eng-26)

(ORNL/TM-5758) Avail: NTIS HC A06/MF A01

The technology and estimated costs of subsystems for storing the thermal energy produced by solar collectors are discussed. The systems considered are capable of producing both electricity and space conditioning for a single family detached residence, an apartment complex of 100 units, and a city of 30,000 residents containing both single family residences and apartments. Up to 36 x 10<sup>6</sup> kWh the 5th power kWhr of thermal storage capacity is required. In addition to sensible heat and latent heat storage materials, several other media were investigated as potential thermal energy storage materials, including the clathrate and semicathrate hydrates, various metal hydrides, and heat storage based on inorganic chemical reactions.

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## "Rolling Cylinder" Heat Storage Device

Mechanical Engineering, vol. 100, no. 3, March 1978  
p. 54-55

Employing special compounds with high heat-storage capacity, GE's "rolling cylinder" system, which is still in the laboratory stage, promises to be low in cost and compact enough to fit conveniently in the basement of most homes and commercial buildings. High cost and prohibitive size are primary disadvantages of present heat-storage systems, which employ large tanks of water or even larger bins of rock.

The experimental rolling cylinder device is designed to accommodate any of a number of heat-storage materials that have high latent heats of fusion. These substances absorb large amounts of heat as they melt. (Heat from the sun would be used for this purpose.) As they cool (after sunset or on cloudy days) the substances gradually solidify, releasing the stored heat.

**A79-31409** Studies on the effect of bed aspect ratios and pressure drop on flow distribution in rock bed storage systems for solar energy applications. A. R. Balakrishnan, H. F. Sullivan, and K. G. T. Hollands (Waterloo, University, Waterloo, Ontario, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 11 p. 5 refs. Department of Supply and Services Contract No. 12SQ-31155-7-4410.

A description is given of an experimental investigation of the flow distribution characteristics across any plane normal to the direction of flow and of the factors which affect these characteristics. The importance of ensuring even or uniform flow distribution to avoid any adverse effect on the thermal performance of the rock bed is pointed out. An indication of the flow distribution, i.e., the relative fluid velocity along a cross-section of the bed, was obtained using thermocouples measuring the air temperature. By monitoring the time taken for the temperature wave in the air stream to pass through a given depth of the bed at a given position in the bed cross-section and comparing this with a similar measurement at another location, a measure of the corresponding air velocities relative to one another is obtained.

G.R.

## TECHNICAL NOTE: EUTECTIC MIXTURES FOR SOLAR HEAT STORAGE.

N. Yoneda & S. Takanashi

Solar Energy, Vol. 21, No. 1, 1978, p. 61-63.

In our work, inorganic eutectic mixtures having melting points in a range most suitable for solar heat storage as well as having high heats of fusion have been probed, and the problems which might arise in the practical application of the mixtures also are studied.

78V36075 1978 ISS: 00 TJ260.T87 0-891680-00-4 621.402  
LC-77-18603

AUTH: A/Turner, Robert H.

UTTL: High temperature thermal energy storage : TLSP:  
including a discussion of TES integrated into power  
plants / Robert H. Turner.  
Franklin Institute Press, Philadelphia : 101 p. : ill.  
: 23 cm.

Solar energy series Includes bibliographical  
references.

LC: Heat storage. Steam power plants.

NASA: / ELECTRIC POWER PLANTS/ ENERGY POLICY/ HEAT  
EXCHANGERS/ HEAT STORAGE/ HIGH TEMPERATURE/ SANDS/  
UNDERGROUND STORAGE

JPL: / TJ260.T850 LA: / TJ260.T76

MAIN-AUTH TRACE-SERS-TITL\* CATLG BY-LC

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**A79-31449** Sensible heat storage for solar energy applications. R. K. Romak and P. P. Von Hatten (Western Ontario, University, London, Canada). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 2. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 8 p.

In the field of solar energy, rocks are the most commonly used media for sensible heat storage. The use of other solid materials has not been adequately considered. This paper studies a group of eight selected materials. These include three sizes of rocks, clay balls, broken drainage tile, brick rubble, iron oxide pellets and blast furnace slag. Initially the materials' properties were analyzed. This was based on size, shape, density and thermal characteristics of the materials. Each material was then tested. A model heat storage unit was constructed to perform heating, cooling and pressure drop tests. These results combined with costs produced the material most suitable. It was found that the ideal material consists of small particles, has high density and heat capacity and packs with a small void ratio. The 3/4 in. stone was selected as most suitable. (Author)

**A79-28783/** Lincoln Lab., Mass. Inst. of Tech., Lexington.  
**CONCEPTUAL DESIGN OF A PACKED BED FOR THERMAL-  
ENERGY STORAGE**

Nigel I. Hamilton 20 Dec. 1978 56 p refs

(Contract EX-76-A-01-2295)

(CAES-10) Avail. NTIS HC A04/MF A01

The design approach, conceptual design, and basic cost estimates for a packed bed for thermal-energy storage in an underground compressed air-storage system are presented. The conceptual designs considered are a 200 MW(e) system operating on a weekly cycle, and a combined solar-thermal/compressed-air-storage system capable of delivering 100 MW(e) to the generator on discharge. Geological stresses in the thermal-energy storage cavity are examined.

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TRANSIENT ANALYSIS OF PACKED-BED THERMAL STORAGE  
SYSTEMS, by M. Riaz  
Solar Energy, vol. 21, no. 2, 1978, p. 123-128

**Abstract**—A one-dimensional single-phase conductivity model of packed beds in which air and rock are at the same temperature is used to develop closed-form analytical solutions for the transient responses produced by time-varying air inlet temperatures. In particular, the single-blow or step response of this simple conductivity model is compared with the classical Schumann two-phase model which ignores axial conductivity. The close agreement exhibited at sufficiently large time justifies the development of approximate equivalent models that combine the effects of air rock heat transfer and axial conductivity.

**A79-31410** Distributed energy storage for solar applications. L. Holt and R. Scheithauer (U.S. Department of Energy, Div. of Energy Storage Systems, Washington, D.C.). In: Renewable alternatives; Proceedings of the Fourth Annual Conference, London, Ontario, Canada, August 20-24, 1978. Volume 1. (A79-31401 12-44) Winnipeg, Solar Energy Society of Canada, Inc., 1978. 9 p. 9 refs.

Energy storage systems have the potential to reduce electric utility peak load burdens and residential customer energy bills by storing electricity during off-peak periods, when generating costs are low, and making the electricity available during peak load periods. Two basic categories of storage systems are related to centralized energy storage at utility power stations and either customer or utility owned decentralized energy storage sited at the location of end use. The reported investigation focuses on distributed (i.e., decentralized) thermal storage for residential applications. Conventional hydro pumped storage is currently the only proven technology and is now in wide use. For the intermediate-term (1985-2000) advanced batteries appear to be attractive. Hydrogen storage system may also prove to be economic. G.R.

**A79-45211** A review of current R&D in thermal energy storage and heat exchange in solar applications. A. I. Michaels (Argonne National Laboratory, Argonne, Ill.). In: Application of solar energy; Proceedings of the Third Southeastern Conference, Huntsville, Ala., April 17-19, 1978. (A79-45201 19-44) Huntsville, Ala., UAH Press, 1978, p. 131-143. 31 refs. Research supported by the U.S. Department of Energy.

The paper reviews the state of advanced technology by presenting a survey of current research and development underway in all of the media and methods used for storing and transferring thermal energy. The thermal energy storage and heat transfer methods discussed are innovative heat exchange and transport, advanced concept sensible heat storage in water, rock, earth or a combination of these, for either short term or for annual storage periods, heat storage in the energy of phase change, and heat storage in the energy of reversible chemical reactions. The material presented is organized in terms of the above categories and subcategories, with the specific R&D projects listed. (Author)

APPLICATIONS OF THERMAL ENERGY STORAGE IN THE PAPER  
AND PULP INDUSTRY, by W. D. Beverly, M. Rubeck and  
G. L. Vieth, P. J. Hurley.  
Journal of Energy, vol. 2, no. 6, Nov.-Dec. 1978,  
p. 375-380.

**T**HE paper and pulp industry in the United States consists of approximately 350 companies operating 750 plants. This industry ranks fifth in the manufacturing group, as well as being one of the largest users of fossil fuels.<sup>1</sup> This paper reports on a study of the applicability of thermal energy storage (TES) in a paper and pulp mill powerhouse, with the intent of reducing fossil fuel usage.

**N78-31628** Pennsylvania State Univ., University Park.  
**TRANSIENT BEHAVIOR OF SOLID SENSIBLE HEAT  
THERMAL ENERGY STORAGE UNITS** Ph.D. Thesis  
Janos Szego 1978 214 p  
Avail. Univ. Microfilms Order No. 78-12080

The geometrical configurations analyzed were the flat-slab and the hollow-cylinder. Both geometries were examined under single fluids and two fluids operation, analytically and experimentally. The energy equation(s) for the fluid(s), coupled to the two dimensional transient conduction equation for the storage material, was solved numerically using finite difference techniques. The parameters that characterize the transient of these units were identified and presented in graphical and tabular form. The results presented can be useful to predict the transient response of a heat storage unit experiencing an arbitrary time varying fluid inlet temperature, by employing superposition techniques. The complete finite difference programs that were developed are able to handle such situations as dissimilar storage materials, irregular geometrical boundaries and time varying inlet fluid temperatures and/or mass flow rates. Dissert. Abstr.

**A79-15866 #** Latent heat storage techniques. M. Telkes (American Technological University, Killeen, Tex.). *Institute of Gas Technology, Energy from the Sun Symposium, Chicago, Ill., Apr. 3-7, 1978, Paper.* 12 p. 13 refs.

The latent heat of fusion or transition of compounds, alloys or eutectics can be calculated from the entropies of fusion of elements forming them. Observed and calculated values are compared to show the accuracy of this method. Latent heat storage materials must meet performance criteria of high heat of fusion per unit weight and volume and low expansion during melting. The obvious requirements must be maintained, using only those materials that are non-combustible, do not explode, are not toxic, caustic or corrosive. Examples of higher temperature materials are shown in graph form. Salt-hydrates are economically and technically most suitable for solar heat storage. Increasing the efficiency of gas-heated domestic furnaces is feasible by storing a major part of the heat, discharged in combustion gases through the stack or chimney. (Author)



SOLAR THERMAL ENERGY STORAGE USING HEAT OF DILUTION:  
ANALYSIS OF HEAT GENERATION IN MULTISTAGE MIXING  
COLUMN, by T. Tanaka, K. Sakuta, M. Kamimoto, T.  
Tani, S. Sawata and T. Horigome.  
Energy Conversion, vol. 18, no. 2, 1978, p. 57-65.

**Abstract**—Storage of solar energy is important for the future success of solar energy utilization systems such as solar thermal power plants. Various papers have described the storage methods for storing solar energy. Because of the results of assessing the storage methods proposed in these papers, the method based on heat of dilution was selected by reasons of the ease of heat transfer, the controllability of reaction and the recovery of heat stored. The effectiveness of heat recovered from heat of dilution in the case of storing solar energy in the form of heat of dilution was considered in this paper. Sulfuric acid and water solution used as the typical example of heat of dilution, since its thermodynamic properties were well known. Two liquids were mixed in two different systems of multistage mixing column, and an application of heat of dilution to multipurpose energy utilization was analyzed. The utility of heat of dilution was explained from the results of thermal characteristics of each system.

**N78-24618\*** Institute of Gas Technology, Chicago, Ill.  
**MOLTEN SALT THERMAL ENERGY STORAGE SYSTEMS**  
Final Report

Hansraj C. Maru, John F. Dullea, Alan Kardas, Larry Paul, Leonard G. Marianowski, Estela Ong, Viji Sampath, Vincent M. Huang, and Jerome C. Wolak. Mar. 1978. 129 p. refs. Sponsored by NASA.

(Contract EY-76-C-02-2888, Proj. 8981)

(NASA CR 135419, COO-2888-3)

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HC A07/MF A01 CSCL 10C

The feasibility of storing thermal energy at temperatures of 450 C to 535 C in the form of latent heat of fusion was examined for over 30 inorganic salts and salt mixtures. Alkali carbonate mixtures were chosen as phase-change storage materials in this temperature range because of their relatively high storage capacity and thermal conductivity, moderate cost, low volumetric expansion upon melting, low corrosivity, and good chemical stability. Means of improving heat conduction through the solid salt were explored. Author

**A78-30264** Demand sensitive energy storage in molten salts. J. J. Nemecek, D. E. Simmons, and T. A. Chubb (U.S. Navy, E. O. Hulburt Center for Space Research, Washington, D.C.). *Solar Energy*, vol. 20, no. 3, 1978, p. 213-217. 5 refs.

Heat-of-fusion energy storage and on-demand steam are obtained by means of heat pipe techniques which transfer heat to and from stacked salt cans and onto boiler tubes within a sealed 'energy storage boiler' tank. The described system consists of a large pressure-tight tank in which containers of salt eutectic are mounted on racks, largely filling the tank. The bottom of the tank contains the energy input region; energy input is effected by the chemical recombination of SO<sub>2</sub> and O<sub>2</sub> to produce SO<sub>3</sub>. Experimental studies using a NaCl-KCl-MgCl<sub>2</sub> eutectic and m-terphenyl as the heat pipe fluid are reported, and the operation of the system is explained. M.L.

**A78-19832** Effects of phase-change energy storage on the performance of air-based and liquid-based solar heating systems. D. J. Morrison and S. I. Abdel-Khalik (Wisconsin, University, Madison, Wis.). *Solar Energy*, vol. 20, no. 1, 1978, p. 57-67. 12 refs. Contract No. E(11-1)-2588.

Models describing the transient behavior of phase-change energy storage (PCES) units are presented. Simulation techniques are used in conjunction with these models to determine the performance of solar heating systems utilizing PCES. Both air-based and liquid-based systems are investigated. The effects of storage capacity, storage unit heat transfer characteristics, collector area and location on the system performance are investigated for systems utilizing sodium sulfate decahydrate and paraffin wax as storage media. Optimum ranges of storage sizes are recommended on the basis of systems' thermal performance. Comparison is made between systems utilizing PCES and those using sensible heat storage, viz. rock beds in air-based systems and water tanks in liquid-based systems. The variation of the solar supplied fraction of load with storage size and collector area is given for systems utilizing both types of storage. The effects of location and collector energy loss coefficient on the relative performance of PCES and sensible heat storage are also investigated. (Author)

**A80-12756** Review of thermal storage materials from the view point of solar energy application. P. C. Pande and H. P. Garg (Central Arid Zone Research Institute, Jodhpur, India). In: *Solar energy for rural development; Proceedings of the National Solar Energy Convention*, Bhavnagar, India, December 20-22, 1978. (A80-12739 02-44) Bhavnagar, India, Central Salt and Marine Chemicals Research Institute, 1979, p. 191-202. 29 refs.

The thermal energy storage and chemical storage of solar energy are reviewed for evaluating the feasibility of its practical utilization in the solar energy devices for agricultural use. Sensible heat and latent heat storage media are considered for high and low thermal storage, and performances of sensible and latent heat materials are compared by investigating their heat capacities, melting points, enthalpies of fusion, densities, stability, corrosion resistance, and thermal conductivities. The hydration-dehydration equilibria are discussed, and storage by inorganic oxide/hydroxide such as MgO/Mg(OH)<sub>2</sub> and CaO/Ca(OH)<sub>2</sub> is investigated. A.T.

**N78-31889** National Standard Reference Data System  
**PHYSICAL PROPERTIES DATA COMPILATIONS RELEVANT TO ENERGY STORAGE. 1. MOLTEN SALTS: EUTECTIC DATA**

George J. Janz, Carolyn B. Allen, Joseph R. Downey, and R. P. T. Tomkins. Mar. 1978. 252 p. refs.  
(PB-280795/6; NSRDS-NBS-61-Pt-1; LC-77-10824)  
Copyright. Avail. NTIS HC A12/MF A01 CSCL 07D

An authoritative compendium of melting points, and compositions of molten salt eutectic mixtures is presented. Data for mixtures melting in the range -138 C to 2800 C are reported. Titles of the articles in the literature citations and a system index are included for approximately 6000 eutectic entries. GRA



A79-42975 Periodic heat storage - Fundamental aspects related to transfer kinetics (Stockage periodique de chaleur aspects fondamentaux lies a la cinetique des transferts). B. Fourcher, B. Cassagne, J. P. Bardon (Nantes, Université, Nantes, France), and J. Bransier (Paris VI, Université, Paris, France). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 4. (A79-42973 18-34) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 155-160. 5 refs. In French.

The kinetics of periodic heat transfer between a heat-carrying fluid and a storage material is examined, with attention to heat conduction within the material and thermoconvective heat exchange at its surface. For the case of sensible heat, storage units of different shapes, including plates, spheres, and cylinders are analyzed, and the effect of nondimensional parameters on the quantity of heat that can be stored by a given system is investigated. The kinetics of latent heat storage in a simple plate is considered, with particular attention to the roles of the Biot number, the Fourier number and the phase change number. Guidelines for the optimization of periodic heat storage elements are developed on the basis of the results. C.K.D.

## USE OF ADSORBENT BEDS FOR ENERGY STORAGE IN DRYING OF HEATING SYSTEMS

D. J. Close and R. V. Dunkle

Solar Energy, vol. 19, no. 3, 1977, p. 233-238

**Abstract**—Energy storage is an important feature of many solar energy systems. Because of the small temperature potentials available from flat plate collectors, large masses and volumes are involved when energy is stored by raising or lowering the temperature of a tank of fluid or bed of gravel. This paper proposes energy storage in the form of heat of adsorption in beds of adsorbent material. This is most readily achieved by nominating water as the adsorbate so that water vapour is transferred to or from the adsorbent from the humid air flowing through the bed. The large heat of adsorption means that the adsorption of a small mass of water liberates a large amount of energy which mostly is transferred to the air stream. It is shown that adsorbing materials can occupy a much smaller volume than non-adsorbing materials for the same quantity of energy stored, and that thermal insulation can be dispensed with. Provided that the container is impervious to water vapour, energy can be stored indefinitely.

✓ 79N78495\* CATEGORY 44 RPT#: NASA-CR-150121  
LMSC-HREC-TR-D497048 IR-2 CNT#: NAS8-31100  
76/10/29 32 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Thermal energy storage TLSP: Interim Report  
AUTH: A/BRODZKA, P. G.; B/CONNER, L. E.  
CORP: Lockheed Missiles and Space Co., Huntsville, Ala.  
AVAIL NTIS  
MAJS: /\*CRYOGENIC FLUID STORAGE/\*HEAT STORAGE/\*THERMAL ENERGY  
MINS: / CHEMICAL REACTIONS/ MULTILAYER INSULATION/ SILICON COMPOUNDS/ SPACE STORAGE

## THERMAL STORAGE: A SLEEPING GIANT. R. T. Tamblyn

Ashrae Journal, June 1977, p. 53-57

*When a capacity module of 1,000 tons or greater is involved, the first cost of chilled water storage of equivalent capacity may be as little as half the cost of a new chiller. When the proposed incremental chiller has electric drive, storage can save in the cost of electric demand. This derives from regenerating storage at night, off peak, by extending the operation of existing chillers. Savings of from 50 to 90% can result in energy cost. The third saving takes place at the electric utility, where no new capacity need be provided for the incremental chilled water requirement. It is the cost of expanding utility capacity which underlies part of the need for increase electric rates today.*

77A49153 ISSUE 23 PAGE 4020 CATEGORY 44  
76/00/00 6 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Thermal energy storage and transportation  
AUTH: A/SEVCIK, V. J. PAA: A/(Argonne National Laboratory, Argonne, Ill.)  
In: Sharing the sun: Solar technology in the seventies; Proceedings of the Joint Conference, Winnipeg, Canada, August 15-20, 1976. Volume 10. (A77-48910 23-44) Cape Canaveral, Fla.: International Solar Energy Society, 1976, p. 177-182.  
ERDA-sponsored research.  
MAJS: /\*AUTOMOBILE ENGINES/\*HEAT STORAGE/\*TRANSPORTATION ENERGY  
MINS: / ELECTRIC AUTOMOBILES/ LITHIUM FLUORIDES/ PROPULSION SYSTEM PERFORMANCE/ STIRLING CYCLE/ STORAGE BATTERIES  
ABA: J.M.B.  
ABS: The application of thermal energy storage concepts to the design of an automobile propulsion system capable of competing with that of electric vehicles is discussed. The proposed vehicle would utilize a thermal storage source, such as a molten salt heat battery, to power a thermal engine. Various materials, including lithium fluoride, sodium chloride, or silicon are considered as candidates for use in the heat batteries; thermal engines based on the Brayton, Rankine, or Stirling cycle are also assessed. It is concluded that a lithium-fluoride battery used in conjunction with a Stirling engine may be the best prospect for development. The reliability, safety and simplicity of the proposed vehicle are analyzed.

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- Intersociety Energy Conversion Engineering Conference, 12th, Washington, 1977.**  
**Proceedings of the 12th Intersociety Energy Conversion Engineering Conference,**
- 779089 — **Molten Salt Thermal Energy Storage for Utility Peaking Loads**, A. A. Ferrara, R. A. Haslett, *Grumman Aerospace Corp.*, Bethpage, N.Y.; J. P. Joyce, *NASA/Lewis* ..... 547
- 779090 — **Latent Heat Thermal Energy Storage Systems Above 450°F**, L. G. Marianowski, H. C. Maru, *Institute of Gas Tech.*, Chicago, Ill. .... 555
- 779091 — **Investigation of Metal Fluoride Thermal Energy Storage Materials**, J. L. Eichelberger, H. D. Gillman, *Pennwalt Corp.*, King of Prussia, Pa. 567
- 779092 — **Safety Considerations for High Temperature Thermal Energy Storage in Fluoride Salts**, O. Boser, *Philips Laboratories*, Briarcliff Manor, N.Y. .... 575
- 779093 — **Large-Scale Thermal Storage in Rock: Construction, Utilization and Economics**, M. P. Hardy, V. D. Albertson, T. P. Bligh, M. Riaz, P. L. Blackshear, *University of Minnesota*, Minneapolis, Minn. .... 583
- 779094 — **Conceptual Design of Underground Compressed Air Storage Electric Power Systems**, A. J. Giramonti, R. D. Lessard, *United Tech. Res. Center*, East Hartford, Conn.; M. J. Hobson, *Acres American Inc.*, Buffalo, N.Y. .... 591
- 779088 — **High-Temperature Thermal Energy Storage System,  $\text{Na}_2\text{SO}_4 + \text{SO}_3 = \text{Na}_2\text{S}_2\text{O}_7$** , R. W. Serth, R. S. Hockett, *Monsanto Research Corp.*, Dayton, O. .... 540

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.S63  
1977
- Society of Engineering Science.**  
Recent advances in engineering science; proceedings of the 14th annual meeting of the Society of Engineering Science, Inc. / edited by G. C. Sih. — Bethlehem, Pa. : Lehigh University, c1977.  
Held November 14-16, 1977 at Bethlehem.  
Includes bibliographical references and index.  
1. Engineering—Congresses. I. Lehigh

The basic parameters of thermal energy storage  
by P. G. Kosky

1293



620

- TH  
7413  
.P37
- Paul, J. K.**  
**Solar heating and cooling : recent advances / J. K. Paul.** -- Park Ridge, N.J. : Hayes Data Corp., c1977.  
— x, 485 p. : ill. ; 24 cm. (Energy technology review ; no. 16)  
ISBN 0-8155-0674-0

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**Macro-Encapsulation of Heat Storage Phase-Change Materials for Use in Residential Buildings. Third Quarterly Progress Report, March 29, 1977--June 29, 1977.**

G. A. Lane, P. B. Hartwick, and H. E. Rossow.  
Dow Chemical Co., Midland, Mich. Aug 77, 24p  
ORO/5217-3 Price code: PC A02/MF A01

Objectives are to assess the feasibility of macro-encapsulated PCMs for residential solar systems and to develop and evaluate such materials. Encapsulant materials under consideration are multilayer flexible plastic films, steel cans, and plastic bottles. PCMs under study are  $\text{Mg}(\text{NO sub 3}) \text{ sub 2} \cdot 6\text{H sub 2 O}$ , naphthalene-benzoic acid eutectic,  $\text{Mg}(\text{NO sub 3}) \text{ sub 2} \cdot 6\text{H sub 2 O} \cdot \text{NH sub 4 NO sub 3}$  eutectic, and  $\text{CaCl sub 2} \cdot 6\text{H sub 2 O}$ . Compatibility studies between the PCMs and encapsulant materials are continuing. A test device has been constructed, and is ready for use. (ERA citation 03:014949)

**DESIGN OPTIMIZATION OF A SINGLE FLUID, SOLID SENSIBLE HEAT STORAGE UNIT.**

F.W. Schmidt, et al.

J. Heat Transfer, v.99, no.2, May 1977, p.174-

*The optimization of the design of a solid sensible heat storage unit initially at a uniform temperature is presented. The storage unit is composed of a number of rectangular cross-sectional channels for the flowing fluid, connected in parallel and separated by the heat storage material. The complex method for constrained nonlinear optimization as presented by M. J. Box is utilized, with some modifications. The design optimization is based upon achieving maximum utilization of the heat storage or removal capabilities of the material for a given set of operating conditions. This is achieved by varying the storage unit's geometry while placing constraints on the maximum and minimum length of the unit, fluid channel size, storage material thickness, maximum and minimum outlet fluid temperature, and the minimum amount of heat to be stored.*

**THERMAL ENERGY STORAGE FOR SOLAR HEATING AND OFF-PEAK AIR CONDITIONING**

Harold G. Lorsch, Kenneth W. Kaufman, and Jesse C. Denton

Energy Conversion, vol 15, no. 1/2, 1977  
p. 1-8

**STORAGE RINGS FOR THERMAL ENERGY**

David Faiman

Solar Energy

Vol. 19

no. 6

1977

p. 743

*If a continuous supply of energy is to be drawn from an intermittent source, some form of intermediate storage system is necessary. This problem arises for example in all terrestrial attempts to utilize solar energy since the insolation at any fixed position on earth is not constant with time.*

*The particular aspect of storage to which we here address our attention, is that of thermal energy. Typically, a volume  $V$  is available and the storage medium is placed in a container whose shape is chosen so as to optimize heat losses and manufacturing costs according to the situation in hand.*

**Technical Note - FUNDAMENTAL STUDIES ON HEAT STORAGE OF SOLAR ENERGY**

T. Tanaka, T. Tani, S. Sawata, K. Sakuta and T. Horigome

Solar Energy, vol. 19, no. 4, 1977, p. 415 - 419

*The authors, therefore, make the fundamental study of the effect of size and thermophysical properties of storage material on the rate of temperature increase and quantity of heat stored in the material. These effects were considered as a problem of unsteady heat conduction in a hollow cylinder and a composite hollow cylinder at the centers of which constant heat flux is supplied. These models make clear the thermal characteristics of storage material and the performance of storage type flat-plate collectors.*

**COMFORT RANGE THERMAL STORAGE**

A. L. Berlad, H. C. Lin, F. J. Salzano, and J. Batey

Energy, vol. 2, no. 2, June 1977, page 161-169.

*The utility of incorporating substantial thermal storage capacity within the externally insulated shell of a residential structure, and within an arbitrarily selected Comfort Range is considered.*



## A DIP IN THE ENERGY STORE

New Scientist, v. 75, no. 1067, September 1, 1977, p. 520-522.

The oil producing nations have shown us what an energy shortage means, but the real energy crisis will arrive in the 21st century. Then the swimming pool could change from being a luxury item into an essential part of the self-sufficient household. As the cost of heat recovery systems falls and prime energy costs rise, the home swimming-pool heat store will become a paying proposition. It no longer makes sense to burn high-grade fuel just to produce low-grade heat (heat at a low temperature) for space heating. As our short period of profligacy draws to an end, the hunt for the energy "holy grail"—the heat store to tide us over till better times—need go no further than the modern swimming pool.

Solar Energy, v.19, 1977, p.721-32.

## A METHOD OF TESTING FOR RATING THERMAL STORAGE DEVICES BASED ON THERMAL PERFORMANCE†

JAMES E. HILL, GEORGE E. KELLY and BRADLEY A. PEAVY

Center for Building Technology, National Bureau of Standards, Washington, DC 20234, U.S.A.

(Received 23 July 1976; in revised form 14 March 1977)

**Abstract**—This paper describes a proposed test method for determining the "effective capacity" and heat loss characteristics of thermal storage devices. The prescribed series of tests should provide useful data for the rating of thermal storage devices based on thermal performance. The apparatuses and major components used in the tests have been prescribed so a liquid or air can be used as the transfer fluid. The series of tests to be conducted consist of one steady-state test to determine the heat loss characteristics and eight transient tests to determine the "effective capacity" for both heat storage and heat removal. During the transient tests, the entering fluid temperature is changed in a step-wise manner and amount of energy either stored or removed over a specified test time is determined. Sample experimental data are given in the paper to demonstrate the concept of the transient tests.

NASA-TP-1074

## A DESIGN HANDBOOK FOR PHASE CHANGE THERMAL CONTROL AND ENERGY STORAGE DEVICES.

W.R. Humphries and Edwin I. Griggs.  
Nov.1977.

This document gives a comprehensive survey of the thermal aspects of devices. Fundamental mechanisms of heat transfer within the phase change Performance in zero-g and one-g fields are examined as it relates to such a device for phase change materials, with metal fillers, undergoing conductive and convective heat transfer. Detailed. Using these models, extensive parametric data are presented for a hybrid with a rectangular phase change housing, using straight fins as the filler, and a phase change material. These data are generated over a range of realistic sizes, and thermal boundary conditions. A number of illustrative examples are given to parametric data. Also a complete listing of phase change material property data as an aid to the reader.

CN-150,840

1977 *Energy storage*

POWER REDUCTION IN RESIDENTIAL AIR CONDITIONING SYSTEMS THROUGH THE USE OF THERMAL ENERGY STORAGE. (Final Rept. prepared for Texas Governor's Energy Advisory Council). Mar. 1977. 59p.

Texas Univ., Austin,  
Center for Energy Studies  
Contract IAC-76-77(1148)

Air conditioning  
Energy conservation - Residential & commercial  
Energy storage

N78-21826/ Toronto Univ. (Ontario). Dept. of Mechanical Engineering.

## DESIGN METHOD FOR HEAT LOSS CALCULATION FOR IN-GROUND HEAT STORAGE TANKS

F. C. Hooper and C. R. Attwater 1977 6 p refs Presented at Winter Ann. Meeting of the Am. Soc. of Mechanical Engineers, Atlanta, Ga., 27 Nov. 1977 (Contract EY-76-C-02-2939)

(COO-2923-3; Conf-771120-4) Avail: NTIS HC A02/MF A01

A lumped parameter approach is used based on three indices evaluated for particular configurations from detailed computations. The method predicts the transient responses of large storages associated with annual heat storage solar heating systems. ERA



Solar Energy, v.19, 1977, p.617-23.

## UNDERGROUND LONGTERM STORAGE OF SOLAR ENERGY—AN OVERVIEW

B. GIVONI

Desert Research Institute, Ben-Gurion University, Beer Sheva, Israel

(Received 14 August 1976; in revised form 28 February 1977)

**Abstract**—The paper describes different options for longterm storage of solar energy, as well as thermal energy from other sources. The various options are analyzed from the viewpoint of their applicability under different climatic and soil conditions.

QD Electrochemical Society.  
552 Extended abstracts...c1977. (Card 2)  
.E42 trolytic, Organic and Biological Electro-  
1977 chemistry, and Physical Electrochemistry  
v.77-1 Divisions.  
1. Electrochemistry--Addresses, essays,  
lectures. 2. Dielectrics--Addresses,  
essays, lectures. 3. Electrolytic  
corrosion--Addresses, essays, lectures.  
537.24

Basic Physical and Chemical Processes for Storage of  
Heat  
G. Alefeld..... 930

Solar Energy, v.19, 1977, p.711-14.

## OPTIMAL PROPORTIONING OF AN INSULATED EARTH CYLINDER FOR STORAGE OF SOLAR HEAT

ROBERT L. NICHOLLS

Department of Civil Engineering, University of Delaware, Newark, DE 19711, U.S.A.

(Received 1 March 1976; in revised form 7 February 1977)

**Abstract**—A technique is illustrated, by means of an example, for optimally proportioning the insulated boundaries of a partially-insulated volume of earth for solar heat storage. The required equations for heat loss rates are determined from electrolytic tank models.

A79-34138

A thermoeconomic analysis of thermal energy storage. K. W. Li (North Dakota State University, Fargo, N. Dak.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9. (A79-34131 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4037-4055. 7 refs.

A simple though general analysis of thermal energy storage systems (TESSs) is presented from a thermoeconomic standpoint. The TESS can be as simple as a hot-water tank with its control valves, or as complicated as an underground compressed-air storage with an upper-level water reservoir to maintain its pressure; the storage medium may be either liquid or vapor and gas. The performance of a TESS is evaluated by the storage system efficiency, defined as the ratio of the thermodynamic availability flow at the exit during the discharge period to the availability flow at the entrance during the charge period. A sensitivity study that provides more information for TESS selection is included. An illustrative example is presented for the break-even cost differential calculations.

S.D.

TJ  
R10  
.A79  
1977

Aspen Energy Forum, 4th, Aspen Institute for  
Humanistic Studies, 1977.

Solar architecture : proceedings of the  
Aspen Energy Forum 1977, May 27, 28, and  
29, 1977, Aspen, Colorado / editors, Gregory  
E. Franta, Kenneth R. Olson ; graphics, T.  
Michael Manchester. — Ann Arbor, Mich. :  
Ann Arbor Science Publishers, c1978.  
ix, 331 p. : ill. ; 24 cm.

EUTECTIC SALT AS A SOLAR HEAT STORAGE MEDIUM . . . 173  
Don M. Harvey

## THERMAL-STORAGE FURNACE

Evan Powell

Popular Science

Vol. 112, no. 5, November 1977,  
p. 70-72.

A new way to store energy  
at night for daytime use  
can help the utilities—and  
you—by leveling demand

Solar Energy, v. 19, 1977, p.677-83.

## PROPOSAL FOR THE PRODUCTION AND SEASONAL STORAGE OF HOT WATER TO HEAT A CITY

G. CAVALLERI

Centro Informazioni Studi Esperienze, Segrate, Milano, Italy and Istituto di Fisica dell'Università di Milano, Italy

G. FOLIGNO

Ditta ing. F. Poggi, Via Casoretto 4623 Milano, Italy

(Received 21 January 1976; in revised form 19 January 1977)

**Abstract**—It is proposed to use an artificial lake, thermally insulated in the upper part only, to be filled during the spring, summer and autumn with hot water at 98°C, as a big storage of heat. Both the lake and the solar collectors should be placed in the mountains in order to exploit the low cost of the land and the higher solar radiation. An aqueduct with a low cost thermal insulation and with a negligible temperature drop even with 100 km length, can heat a city with more than 1 million people. In order to extract the maximum heat from the water, the aqueduct first feeds usual heaters then, in cascade, radiating panels and finally warm air conditioners equipped with a heat pump so that the discharged water is at 5°C. Convenient solar collectors to be placed in the mountains and for large production of hot water are the ones with concentration by fixed cylindrical mirrors. The design of the relevant moving tubular boiler is presented. The estimated cost per person is half of the cost required by a conventional heating system.

## MEASUREMENT OF ROCK PILE HEAT TRANSFER COEFFICIENTS

Elvio Alanis, Luis Saravia and Leticia Rovetta  
Solar Energy  
Vol. 19, no. 5, 1977  
p. 571-572

The use of rock pile heat storage systems has been considered for different solar energy applications[1-3]. Experimental data for the heat transfer coefficient  $h$ , between air and rocks of irregular shape are scarce. Löf and Hawley[4] have obtained experimental results for the type of rock beds most commonly used in solar energy storage. Kays and London[5] correlate data for packed beds from different sources. Dunkle and Ellul[6] have proposed the use of the equation obtained by Kays and London[5] for the design of randomly-packed beds.

The authors have had the opportunity to test some rock piles in the northwest part of Argentina, where the easily available native gravel is composed of smooth rounded river pebbles. Some results for the heat transfer coefficients  $h$ , were obtained for values of the air velocity lower than those used by Löf and Hawley[4].

(over)

N77-33613/ Xerox Electro-Optical Systems, Pasadena, Calif.  
**THERMAL ENERGY STORAGE DEMONSTRATION UNIT  
FOR VUILLEUMIER CRYOGENIC COOLER** Interim Report,  
2 Jun. 1976 - 31 Aug. 1976  
Robert Richter Feb. 1977 157 p  
(Contract F33615-75-C-2045)  
(AD-A040895; Rept-2340-1-1; AFAPL-TR-76-110) Avail: NTIS  
HC A08/MF A01 CSCL 10/2

This report covers the work performed under the Thermal Energy Storage Demonstration Unit Program. The report presents the analysis, design, fabrication, and testing of a thermal energy storage demonstration unit which was to be mated to an existing Vuilleumier cooler (AFJIR) to demonstrate the concept of powering such a device directly with stored thermal energy. The Thermal Energy Storage Demonstration Unit was to be sized for delivering 1000 watts thermal power for one hour at a temperature of 1250 + or - 25 F. The ternary eutectic 64 MgF2 - 30 LiF-6 KF, which has a eutectic temperature of 1310F, was selected as the thermal energy storage material. The report presents the approach and the assumptions underlying the design of the unit which incorporates a heat pipe for the transfer of energy from the thermal energy storage material to the hot cylinder of the

## EXPERIMENTAL STUDY OF THERMALLY STRATIFIED HOT WATER STORAGE TANKS

Z. LaVan and J. Thompson  
Solar Energy  
Vol. 19, no. 5 1977  
p. 519-524

**Abstract**—Temperature stratification in hot water storage systems was studied experimentally. In particular, high extraction rates from plastic cylindrical vessels were emphasized. Data were taken at various length to diameter ratios, inlet-outlet temperature differences and mass flow rates. The effect of inlet and exit port configuration on thermal stratification was also studied. The data were empirically correlated to yield useful relations for the design of effective hot water storage systems. Finally, a novel inlet and exit configuration scheme was designed for an 80 gal. (300 L) and a 500 gal. (1900 L) storage tank.

TJ  
153  
.E4783  
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Energy Development III / sponsored by the IEEE  
Energy Development Subcommittee of the IEEE  
Power Generation Committee of the IEEE Power  
Engineering Society. — New York : Institute  
of Electrical and Electronics Engineers,  
c1977.

176 p. : ill. ; 28 cm. — (IEEE Power  
Engineering Society Papers ; 3)  
"77CH1215-3-PWR"

Storage of Off-Peak Thermal Energy in Oil, by Robert P. Cahn and E.W. Nicholson.

p. 86 -

77A50217 ISSUE 24 PAGE 4186 CATEGORY 44  
77/00/00 2 PAGES UNCLASSIFIED DOCUMENT

UTTL: Measurement of rock pile heat transfer coefficients  
--- heat storage in gravel

AUTH: A/ALANIS, E.; B/SARAVIA, L.; C/ROVETTA, L. PAA:  
C/(Salta, Universidad Nacional, Salta, Argentina)  
Solar Energy, vol. 19, no. 5, 1977, p. 571, 572.

MAJS: /\*GRAVELS/\*HEAT STORAGE/\*HEAT TRANSFER COEFFICIENTS

MINS: / AIR FLOW/ HEAT MEASUREMENT/ REYNOLDS NUMBER/ STANTON  
NUMBER

ABA: F.G.M.

ABS: Heat-transfer coefficients of rock piles consisting of  
pebbles of two different sizes are measured using a  
transient method whereby a temperature step is applied  
to a rock bed, and the time-temperature relations  
obtained for a fluid at different points in the pile  
are compared with theoretical curves. Results obtained  
for air velocities of 0.02 to 0.12 m/s and air  
temperatures of 18 to 67 C are presented in terms of  
the dimensional volumetric heat-transfer coefficients  
and ratios between the mass velocity of a gas on a  
frontal-area basis and the equivalent spherical  
diameter of a particle as well as in terms of the  
dimensionless Stanton and Reynolds numbers. These  
results are shown to be somewhat higher than those  
reported by Loef and Hawley (1948) and those proposed  
by Kays and London (1964).

77N33616# ISSUE 24 PAGE 3237 CATEGORY 44 RPT#:  
PB-267281/4 NBSIR-77-1237 77/05/00 32 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Transpiration heat transfer in thermal energy storage  
devices

AUTH: A/PEAVY, B. A.; B/DRESSLER, W. E.  
CORP: National Bureau of Standards, Washington, D.C.

AVAIL. NTIS SAP: HC A03/MF A01

MAJS: /\*HEAT STORAGE/\*HEAT TRANSFER/\*THERMODYNAMIC  
EFFICIENCY

MINS: / ENERGY STORAGE/ MATHEMATICAL MODELS/ SOLAR HEATING

ABA: GRA

ABS: Sensible heat transfer that takes place in a thermal  
storage device composed of a porous material with a  
fluid transpiring through it was investigated.  
Experiments were performed on a prototype thermal  
storage device and results were compared to numerical  
values computed from an analytical model.

78A11308 ISSUE 1 PAGE 74 CATEGORY 44 CNT#:  
EY-76-S-02-4009 77/00/00 5 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Rock properties for thermal energy storage systems in  
the 0 to 500 C range

AUTH: A/PFANNKUCH, H. O.; B/EDENS, M. H. PAA:

B/(Minnesota, University, Minneapolis, Minn.)

In: International Solar Energy Society, Annual  
Meeting, Orlando, Fla., June 6-10, 1977, Proceedings,  
Sections 14-25. (A78-11212 01-44) Cape Canaveral,  
Fla., International Solar Energy Society, 1977, p.  
18-5 to 18-9.

MAJS: /\*CONDUCTIVE HEAT TRANSFER/\*HEAT STORAGE/\*ROCKS/\*  
THERMOPHYSICAL PROPERTIES

MINS: / CHEMICAL COMPOSITION/ DENSITY (MASS/VOLUME)/  
DIFFUSIVITY/ MINERALS/ SOLAR ENERGY CONVERSION/  
SPECIFIC HEAT/ TEMPERATURE EFFECTS/ THERMAL  
CONDUCTIVITY/ THERMAL CYCLING TESTS

ABA: (Author)

ABS: Thermophysical properties of rocks depend strongly on  
their mineral composition, the storage temperature,  
and on the history of periodic temperature application  
(cycling). Long-term and large-scale rock bed thermal  
storage systems expect operating ranges between 200 C  
and 500 C, for which little and only scattered  
information is available. This paper presents a  
collection and critical review of experimental data  
from the literature on specific heat, thermal  
conductivity and diffusivity of representative rock  
forming minerals and dense (nonporous) rocks between  
ambient and 773 K.

79N71269# CATEGORY 44 RPT#: SAN-1109-B/7 CNT#:  
EY-76-C-03-1109 77/05/01 707 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Solar pilot plant, phase 1. Preliminary design  
report. Volume 5: Thermal storage subsystem. CDRL  
Item 2

CORP: Honeywell, Inc., Minneapolis, Minn. CSS: (Energy  
Resources Center.) AVAIL. NTIS

MAJS: /\*HEAT STORAGE/\*PILOT PLANTS/\*SOLAR ENERGY CONVERSION  
/\*SYSTEMS ENGINEERING

MINS: / ELECTRIC POWER PLANTS/ ENERGY TECHNOLOGY/ INORGANIC  
COMPOUNDS



78A11295 ISSUE 1 PAGE 72 CATEGORY 44 77/00/00  
5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Efficiency of paraffin wax as a thermal energy storage system

AUTH: A/FONG, A. D.; B/MILLER, C. W. PAA: B/(California, University, Berkeley, Calif.)  
In: International Solar Energy Society, Annual Meeting, Orlando, Fla., June 6-10, 1977, Proceedings, Sections 14-25. (A78-11212 01-44) Cape Canaveral, Fla., International Solar Energy Society, 1977, p. 16-6 to 16-10.

ABA: (Author)

ABS: A study of paraffin wax as a thermal energy storage medium was conducted to determine the performance of the wax as compared to water. The particular wax used, with 205 KJ/kg contained within a heat of fusion range extending from 45 C to 63 C, had a thermal energy storage capacity that was approximately 2.5 times greater than that of water in the same temperature range. Heat storage and heat removal tests yielded performance coefficients of 0.5 to 0.6 in this region. This coefficient could be increased by an improved heat exchanger design. By studying the effect of different heat exchanger configurations, an improved design was determined which would increase the melting process. Cells, of aspect ratio (height/width) on the order of 1, were used to help enhance the convection heat transfer.

TJ  
810  
.S48  
1976  
v.10  
Business, commercial, poster session, miscellaneous : joint conference, American Section, International Solar Energy Society and Solar Energy Society of Canada, inc., August 15-20, 1976, Winnipeg / editor, K. W. Boer. — Cape Canaveral, Fla. : American Section of the International Solar Energy Society, c1976.

HEAT TRANSFER CHARACTERISTICS OF A LATENT-HEAT STORAGE SYSTEM NEAR EQUILIBRIUM STATE 171

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TJ  
810  
.S48  
1976  
v.8

Storage, water heater, data communication, education : joint conference, American Section, International Solar Energy Society and Solar Energy Society of Canada, inc., August 15-20, 1976, Winnipeg / editor

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ENERGY STORAGE SYSTEM

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77A49100 ISSUE 23 PAGE 4016 CATEGORY 44  
76/00/00 25 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Chemical methods of storing thermal energy  
AUTH: A/OFFENHARTZ, P. O'D. PAA: A/(EIC Corp., Newton,  
Mass.)  
In: Sharing the sun: Solar technology in the  
seventies: Proceedings of the Joint Conference,  
Winnipeg, Canada, August 15-20, 1976. Volume 8.  
(A77-48910 23-44) Cape Canaveral, Fla., International  
Solar Energy Society, 1976, p. 48-72.  
MAJS: /\*CHEMICAL ENERGY/\*CHEMICAL REACTIONS/\*ENERGY  
TECHNOLOGY/\*HEAT STORAGE/\*THERMAL ENERGY/\*  
THERMOCHEMICAL PROPERTIES  
MINS: / COST EFFECTIVENESS/ DEHYDRATION/ HEAT PIPES/ HEAT  
PUMPS/ HEAT SINKS/ HEAT SOURCES/ HYDRATION/ HYDROGEN  
PRODUCTION  
ABA: (Author)  
ABS: Thermal energy storage through chemical reactions is  
reviewed including second-law restrictions and  
opportunities. Second-law opportunities arise when the  
collection temperature exceeds the utilization  
temperature; in this case a thermochemically driven  
heat pump can be used to deliver considerably more  
heat than is collected. Chemical reactions can be  
chosen to fit the source and sink temperatures so as  
to amplify the input heat. A number of currently  
proposed methods (H2 generation and storage,  
hydration-dehydration equilibria, chemical heat pipes,  
and ammoniacal salt pairs) are assessed with respect  
to efficiency, cost, chemical feasibility, and  
suitability for various collection and utilization  
temperatures.

77V19977 1976 ISS: 05 TJ153.N37 621.4  
AUTH: A/Kovach, Eugene G. PAT: A/ed.  
UTTL: Thermal energy storage; TLSP: the report of a NATO  
Science Committee Conference held at Turnberry,  
Scotland, 1st-5th March, 1976.  
North Atlantic Treaty Organization. Science Committee.  
NATO Science Committee Conference on Thermal Energy  
Storage, Turnberry, Scotland, 1976.  
NATO Scientific Affairs Division, Brussels: 75 p.  
Includes bibliographical references.  
LC: Energy conservation--Congresses. Heat storage  
devices--Congresses. Energy storage--Congresses.  
Conferences--Turnberry, Scotland.  
NASA: / CONFERENCES/ ENERGY CONSERVATION/ ENERGY  
STORAGE/ HEAT STORAGE/ HEAT TRANSFER/ HIGH TEMPERATURE  
ENVIRONMENTS/ LOW TEMPERATURE ENVIRONMENTS/ THERMAL  
ENERGY  
AM-ATL: / TJ260.N38 1976 JPL: / TJ260.C148 1976 JSC: /  
TJ260.N86  
MAIN-MEET TRACE-CORP-TITL-AUTH\* CATLG BY-LC  
77/01/31 Publ In BELGIUM AVAIL: / AMES-ATL/ JOHNSON/  
JPL/ LANGLEY/ LEWIS

77N10675# ISSUE 1 PAGE 94 CATEGORY 44 RPT#:  
PB-252592/1 NSF/RANN/SE/AER74-09186 NSF/RA/N-75-231  
CNT#: NSF AER-74-09186 75/11/00 45 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Two component thermal energy storage material TLSP:  
Final Report

AUTH: A/MEHALICK, E. M.; B/TWEEDIE, A. T.  
CORP: General Electric Co., Philadelphia, Pa. CSS: (Space  
Div.) AVAIL NTIS SAP: HC A03/MF A01  
Sponsored in part by ERDA

MAJS: /\*HEAT STORAGE/\*PARAFFINS/\*SOLAR ENERGY ABSORBERS  
MINS: / ENCAPSULATING/ ENVIRONMENTAL TESTS/ HEAT TRANSFER/  
SLURRIES/ SOLAR HEATING/ SPECIFIC HEAT/ WATER

ABA: GRA

ABS: A thermal energy storage medium consisting of a slurry  
of spherically shaped capsules of encapsulated  
paraffin in a water carrier combines the advantages of  
the heat capacity of a phase change material and the  
high heat transfer rate of a slurry. The feasibility  
of this concept was evaluated by subjecting samples of  
such slurries to simulated solar system environmental  
conditions which included thermal cycling, system  
temperature levels, and slurry flow agitation due to  
stirring and pumping. The results of the evaluation  
program showed that paraffin can be encapsulated with  
a wall durable enough to withstand the temperature,  
thermal cycling, and moderate agitation without  
damage. The slurry storage capacity was also shown to  
be a factor of two higher than a water system on a per  
unit volume basis, assuming a 20F temperature change  
and a 40% solids slurry. The potential exists for even  
higher storage capacities at higher solids  
concentration levels.

## ENERGY STORAGE - COMPRESSED AIR AND PUMPED

79A46308 ISSUE 20 PAGE 3786 CATEGORY 44  
79/04/00 16 PAGES UNCLASSIFIED DOCUMENT

UTTL: Design of optimum compressed air energy-storage systems

AUTH: A/SHARMA, A.; B/CHU, H. H.; C/AHRENS, F. W.;  
D/AHLUWALIA, R. K.; E/RAGSDALL, K. M. PAA:  
B/(Illinois, University, Chicago, Ill.); D/(Argonne  
National Laboratory, Argonne, Ill.); E/(Purdue  
University, West Lafayette, Ind.)  
(University of Illinois and U.S. Department of Energy,  
Midwest Energy Conference, Chicago, Ill., Nov. 19-21,  
1978.) Energy (UK), vol. 4, Apr. 1979, p. 201-216.  
Research supported by the U.S. Department of Energy.

MAJS: /\*COMPRESSED AIR/\*ENERGY STORAGE/\*OPTIMIZATION/\*  
PERFORMANCE PREDICTION/\*SYSTEMS ENGINEERING  
MINS: / BLOCK DIAGRAMS/ ENERGY TECHNOLOGY/ MATHEMATICAL  
MODELS/ TABLES (DATA)/ UTILITIES

ABA: (Author)

ABS: Compressed air energy storage (CAES) power systems are being considered by electric utilities for load-leveling application. Their economic benefit and the extent of premium fuel conservation is dependent on their design. An optimum design approach for CAES is presented in this paper. It is based on decomposition of the overall CAES plant/utility grid system into three partially-decoupled subsystems. Technical and economic models of the subsystems are used in a constrained optimization procedure. The constraints are imposed by the physical characteristics of the subsystems, by interaction among the subsystems and by the interfacing requirements imposed by the utility. To illustrate the concepts, models for the system comprising the compressor train, piping, and an aquifer reservoir have been used in the optimization procedure. Results from these studies show that substantial reductions in capital cost and total operating cost can be achieved using optimization techniques.

79A51801 ISSUE 23 PAGE 4374 CATEGORY 44  
79/00/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: Study of turbomachinery options for compressed air energy storage plants

AUTH: A/KARTSOUNES, G. T.; B/KIM, C. S. PAA: B/(Argonne  
National Laboratory, Argonne, Ill.)  
In: Intersociety Energy Conversion Engineering  
Conference, 14th, Boston, Mass., August 5-10, 1979,  
Proceedings, Volume 1. (A79-51726 23-44) Washington,  
D.C., American Chemical Society, 1979, p. 455-456.  
Research supported by the U.S. Department of Energy.

MAJS: /\*COMPRESSED AIR/\*ENERGY STORAGE/\*POWER PLANTS/\*  
TURBOMACHINERY

MINS: / COST ANALYSIS/ ENERGY TECHNOLOGY/ PRESSURE  
DISTRIBUTION/ UNDERGROUND STORAGE

ABA: M.E.P.

ABS: A study of possible turbomachinery options for compressed air energy storage (CAES) plants is presented. Particular emphasis is placed on the turbine system of the plant. Plant performance is presented in terms of five parameters: (1) specific air flow rate, (2) heat rate, (3) storage volume, (4) compression rate, and (5) overall plant efficiency. It is concluded that optimum performance results from high storage pressure and high inlet gas temperatures to the turbines. The economic analysis, however, illustrates that minimum cost does not necessarily correspond to optimum plant performance. It is shown that presently available conventional turbomachinery with proven reliability is competitive with advanced concepts.

BN14534# ISSUE 5 PAGE 622 CATEGORY 44 RPT#:  
PNL-2935 CNT#: EY-76-C-06-1830 79/06/00 180 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Compressed air energy storage technology program ---  
concept for supplying electric power to meet peak load  
demands TLSP: Annual Report, 1978

AUTH: A/LOSCUTOFF, W. V.

CORP: Battelle Pacific Northwest Labs., Richland, Wash.

AVAIL NTIS SAP: HC A09/MF A01

MAJS: /\*COMPRESSED AIR/\*ELECTRIC POWER PLANTS/\*ENERGY  
STORAGE/\*UNDERGROUND STORAGE

MINS: / COAL UTILIZATION/ ENERGY TECHNOLOGY/ SOLAR  
COLLECTORS/ THERMAL ENERGY/ UTILITIES

ABA: J.M.S.

ABS: Results of studies performed to establish design and  
stability criteria for compressed air energy storage  
(CAES) underground reservoirs are presented along with  
advanced concepts that will eliminate dependence of  
the CAES concept on petroleum fuels. Reservoirs  
examined include aquifers, hard rock caverns, and salt  
caverns. Equipment evaluation and development studies  
are cited together with feasibility studies of  
alternative fuels and technologies such as adiabatic  
systems, hybrid systems utilizing thermal energy  
storage and fuel, coal fired fluidized processes, and  
coal fired low Btu gasifiers.

EIGHTY ATMOSPHERES IN RESERVE.

EPRI Journal, vol 4, no 3, April 1979, p. 14-18.

EPRI, DOE, and several utilities  
are exploring the use of  
compressed air in underground  
reservoirs as an energy storage  
option.

78A40823# ISSUE 17 PAGE 3122 CATEGORY 44  
78/06/00 10 PAGES UNCLASSIFIED DOCUMENT

UTTL: Performance characteristics of compressed air energy  
storage systems

AUTH: A/DECHER, R.; B/DAVIS, R. N. PAA: B/(Washington,  
University, Seattle, Wash.)

Journal of Energy, vol. 2, May-June 1978, p. 165-174.

MAJS: /\*COMPRESSED AIR/\*ELECTRIC GENERATORS/\*ENERGY STORAGE  
/\*THERMODYNAMIC EFFICIENCY

MINS: / DESIGN ANALYSIS/ ENERGY TECHNOLOGY/ MATHEMATICAL  
MODELS/ PERIODIC VARIATIONS/ PRESSURE EFFECTS/  
PRESSURE VESSEL DESIGN/ TEMPERATURE EFFECTS/ TIME  
DEPENDENCE

ABA: S.D.

ABS: The paper examines the thermodynamic performance  
potential of compressed-air energy-storage (CAES)  
systems considered as effective means of dealing with  
the peak-power problem because of the availability of  
required system components, minor need for new  
technology, and potentially attractive cost. The study  
focuses on a mathematical description of the CAES  
system and on identification of relevant parameters  
governing the system performance. The impact of power  
pulse shape and the role of thermodynamic parameters  
are stressed. For the small vessel, the problem of  
matching thermocomponents is discussed. The ratio of  
cyclic energy stored to the volume available is  
considered an important parameter governing the  
thermodynamic performance and cost. To maximize  
performance, intercooling the compressor is most  
effective, especially when vessel pressures are high.  
Regeneration is cost effective only if the vessel  
pressure is low. A CAES system should be operated at  
an energy density per unit pressure as low as  
possible.

79N24487# ISSUE 15 PAGE 2005 CATEGORY 44 RPT#:  
PNL-2871 CNT#: EY-76-C-06-1830 78/03/00 90 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Preliminary long-term stability criteria for  
compressed air energy storage caverns in salt domes

AUTH: A/THOMS, R. L.; B/MARTINEZ, J. D.

CORP: Louisiana State Univ., Baton Rouge, CSS: (Inst. for  
Environmental Studies.) AVAIL NTIS SAP: HC A05/MF  
A01

MAJS: /\*COMPRESSED AIR/\*ENERGY STORAGE/\*LONG TERM EFFECTS/\*  
STORAGE STABILITY

MINS: / CAVES/ MAINTENANCE/ PERFORMANCE/ TECHNOLOGY  
ASSESSMENT

ABA: DOE

ABS: A methodology for determining the long-term stability

of site specific compressed air energy storage cavern  
systems in salt domes is presented. Results of a  
literature survey are given.



✓ 78A20788# ISSUE 7 PAGE 1206 CATEGORY 44 RPT#:  
ATAA PAPER 78-281 78/01/00 15 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Mechanical energy storage systems - Compressed air and underground pumped hydro

AUTH: A/CHIU, H. H.; B/RODGERS, L. W.; C/SALEEM, Z. A.;  
D/AHLUWALIA, R. K.; E/KARTSOONES, G. T.; F/AHRENS,  
F. W. PAA: D/(Illinois, University, Chicago, Ill.);  
F/(Argonne National Laboratory, Argonne, Ill.)

American Institute of Aeronautics and Astronautics,  
Aerospace Sciences Meeting, 16th, Huntsville, Ala.,  
Jan. 16-18, 1978, 15 p. ERDA-supported research.

MAJS: /\*COMPRESSED AIR/\*ECONOMIC ANALYSIS/\*ENERGY STORAGE/\*  
PUMPING/\*UNDERGROUND STORAGE

MINS: / ELECTRIC POWER/ HYDROELECTRIC POWER STATIONS/  
UTILITIES

ABA: (Author)

ABS: Compressed air and underground pumped hydro storage are near-term load-leveling and peak-shaving technologies that are being considered by electric utilities. Assessments of the technical and economic feasibility of these storage systems have concluded that no major technical barriers for their implementation exist and that the systems are economically competitive with conventional peaker plants. This paper reviews and compares the characteristics of these two energy storage systems, evaluates their potential impacts, and presents recent research results with particular emphasis on air storage technology. In addition, advanced concepts and technical areas, where further work would be beneficial, are discussed.

✓ 79N27689# ISSUE 18 PAGE 2434 CATEGORY 44 RPT#:  
EPRI-EM-877 78/08/00 68 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: Geologic assessment of compressed air storage sites in Kansas TLSP: Final Report

AUTH: A/BERWIG, D.

CORP: Black and Veatch Consulting Engineers, Kansas City,  
Mo. AVAIL:NTIS SAP: HC A04/MF A01  
Sponsored by EPRI

ABA: DOE

ABS: The work that was completed on the geological assessment of compressed air energy storage (CAES) in Kansas is described. The work consisted of four tasks: (1) a detailed review was made of the power generation and transmission requirements of the Kansas Utility System; (2) based on the design and operational requirements of CAES reference plants, technical, economic, and environmental site selection criteria and a site selection procedure were established; (3) candidate sites were selected and evaluated using the economic criteria developed; and (4) a site development schedule and field investigation program were developed for an air reservoir located in salt.

✓ 78A31364# ISSUE 12 PAGE 2195 CATEGORY 44  
78/02/00 4 PAGES In RUSSIAN UNCLASSIFIED DOCUMENT

UTTL: Analytic determination of the fuel effect of air storage gas turbine electric power stations

AUTH: A/NAKSUDIAN, A. S.; B/ALANIAN, Z. A.; C/BOIADZHIAN,  
A. G. PAA: C/(Nauchno-Issledovatel'skii Institut  
Energoset'proekt, Armenian SSR)

Teploenergetika, Feb. 1978, p. 70-73. In Russian.

MAJS: /\*COMPRESSED AIR/\*ELECTRIC POWER PLANTS/\*ENERGY  
STORAGE/\*FUEL CONSUMPTION/\*GAS TURBINES

MINS: / AUXILIARY POWER SOURCES/ ENERGY REQUIREMENTS/ ENERGY  
TECHNOLOGY

ABA: P.T.A.

ABS: Air storage electric power stations operate to cover the peak loads of power systems and to balance out the nighttime dips. The amount of peak power developed by an air storage power installation significantly exceeds the required off-peak power. The fuel effect

of air storage power stations is positive. The specific fuel saving in comparison with the alternative of water storage and supplementary gas turbine plant amounts to 0.03-0.125 kg fuel per kilowatt-hour. Regenerative heating of air leads to a sharp reduction in fuel consumption during unloading of an air storage power station.

**N80-11625#** Argonne National Lab., Ill. Energy and Environmental Systems Div.

**EVALUATION OF TURBOMACHINERY FOR COMPRESSED AIR ENERGY STORAGE PLANTS**

George T. Kartsounes and Choong S. Kim 1978 11 p refs  
Presented at Mech. and Magnetic Energy Storage Contractors Inform. Exchange Conf., Luray, Va., 24-26 Oct. 1978

(Contract W-31-109-eng-38)

(CONF-781046-6) Avail: NTIS HC A02/MF A01

Turbomachinery options for compressed air energy storage plants are presented. The plant is divided into four subsystems: a turbine system, compressor system, motor/generator, and an underground air storage reservoir. Plant performance is presented in terms of five parameters: specific air flow rate, specific heat rate, specific storage volume, specific compression rate, and overall plant efficiency. The capital and operating costs of the plant as a function of the turbomachinery options are presented. DOE

**N78-33548#** Battelle Pacific Northwest Labs., Richland, Wash.  
**COMPRESSED AIR ENERGY STORAGE ADVANCED SYSTEMS ANALYSIS Progress Report, FY 1977**

D. K. Kreid and M. A. McKinnon Mar. 1978 133 p refs  
(Contract EY-76-C-06-1830)

(PNL-2464) Avail: NTIS HC A07/MF A01

Technologies that will reduce the consumption of natural gas and oil are reviewed. Major areas of interest for the compressed air energy storage (CAES) program are: cost assessment for thermal energy storage (TES) systems that are suitable for CAES applications; potential fuel savings of hybrid CAES cycles that incorporate TES for recovery of the heat of compression and estimate the economic incentive for using TES in CAES systems; and modified CAES cycles that eliminate the use of gas and oil by the use of alternative fuels. ERA

**N78-30821#** Argonne National Lab., Ill.  
**USE OF RECIPROCATING ENGINES IN COMPRESSED AIR ENERGY STORAGE POWER PLANTS**

G. T. Kartsounes and J. G. Daley 1978 36 p refs Presented at CAES Technol. Symp., Pacific Grove, Calif., 15 May 1978  
(Contract W-31-109-eng-38)

(CONF-780599-4) Avail: NTIS HC A03/MF A01

The application of reciprocating engines to compressed air energy is described. The expected advantages compared to conventional turbines and compressors are reduced reservoir size and cost, reduced equipment cost, reduced compression energy, increased overall plant efficiency, and increased energy storage effectiveness. The performance of possible engine and plant configurations are presented. One possible configuration is the use of a reversible expander/compressor engine; another is a hybrid reciprocating engine-turbomachinery concept. Capital and operating costs are also estimated and compared with that of conventional CAES plant designs. DOE

**PERFORMANCE CHARACTERISTICS OF COMPRESSED AIR ENERGY STORAGE SYSTEMS.**

R. Decher & R. N. Davis

Journal of Energy, Vol. 2, No. 3, May/June 1978, p. 165-174.

The purpose of this paper is to examine the performance potential of compressed air energy storage (CAES) systems. Such systems have been proposed<sup>46</sup> as effective means of dealing with the peak power problem because of the availability of the required system components, the minor need for new technology, and the potentially attractive cost. Specifically, the characteristics of such systems using various assemblies of components are to be examined to identify the role played by system parameters such as size and pressure, and by loss mechanisms such as component inefficiencies and heat transfer. This approach is judged more practical than more general second-law analyses, as described in Ref. 7—for example, for the identification of the components whose performance improvement will play an important role in system performance improvement.

**A79-46308**

**Design of optimum compressed air energy storage systems.** A. Sharma, H. H. Chu (Illinois, University, Chicago, Ill.), F. W. Ahrens, R. K. Ahluwalia (Argonne National Laboratory, Argonne, Ill.), and K. M. Ragsdell (Purdue University, West Lafayette, Ind.). (University of Illinois and U.S. Department of Energy, Midwest Energy Conference, Chicago, Ill., Nov. 19-21, 1978.) Energy (UK), vol. 4, Apr. 1979, p. 201-216. 31 refs. Research supported by the U.S. Department of Energy.

Compressed air energy storage (CAES) power systems are being considered by electric utilities for load-leveling application. Their economic benefit and the extent of premium fuel conservation is dependent on their design. An optimum design approach for CAES is presented in this paper. It is based on decomposition of the overall CAES plant/utility grid system into three partially decoupled subsystems. Technical and economic models of the subsystems are used in a constrained optimization procedure. The constraints are imposed by the physical characteristics of the subsystems, by interaction among the subsystems and by the interfacing requirements imposed by the utility. To illustrate the concepts, models for the system comprising the compressor train, piping, and an aquifer reservoir have been used in the optimization procedure. Results from these studies show that substantial reductions in capital cost and total operating cost can be achieved using optimization techniques. (Author)

## COMPRESSED AIR ENERGY STORAGE

K. G. Vosburgh

J. Energy, vol. 2, no. 2, March-April 1978, p.106-112

**C**OMPRESSED air energy storage (CAES) is a system for electric utility application that permits the storage of energy generated during low-demand periods. Air is compressed during low-demand periods by motor-driven compressors, and is stored underground. When power is required, the air is heated by burning fuel in combustion chambers, and then the air expands through the turbines to drive electric generators. The CAES technology is one of the most attractive near-term options for electric utility storage.<sup>1</sup> This is reflected in the current construction of a CAES plant in Germany<sup>2</sup> and the present American program of demonstration plant designs.

N80-11624# Argonne National Lab., Ill.

### UNDERGROUND PUMPED HYDRO STORAGE: AN OVERVIEW

S. W. Tam, C. A. Blomquist, and G. T. Kartsounes 1978 13 p refs Presented at the 1st Inform. Exchange Conf., Luray, Va., 24 Oct. 1978

(Contract W-31-109-eng-38)

(CONF-781046-1) Avail: NTIS HC A02/MF A01

The status of underground pumped hydro storage (UPHS) for electric utility peaking and energy storage applications is reviewed. The salient features of major recent studies are reviewed. Turbomachinery options and advances in high head pump/turbines are discussed. The effect of head, capacity, turbomachinery unit size and type, and other performance variables on the cost of a UPHS plant are presented. Market potential, siting criteria, lower reservoir construction, and geological related issues are addressed. The environmental impact of a UPHS plant is reduced from comparable facilities, and these issues and other safety concerns are presented. DOE

## POTENTIAL FOR CONVENTIONAL AND UNDERGROUND PUMPED-STORAGE.

A. E. Allen

IEEE Transactions on Power Apparatus and System, vol. PAS-96, no. 3, May/June 1977, p. 993 - 998

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Energy Technology Conference, 5th, Washington, D.C., 1978.

Energy technology V : challenges to technology : proceedings of the fifth Energy Technology Conference, February 27-March 1, 1978, Washington, D.C. / edited by Richard F. Hill. -- Washington : Government Institutes, 1978.

xiii, 1063 p. : ill.

1. Power (Mechanics)—Congresses.

POWER GENERATION USING THERMAL VAPOR PUMPING AND HYDRO-PUMPED STORAGE

Sidney A. Parker, 21st Century Power Generation Co.

p. 786

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Intersociety Energy Conversion Engineering Conference, 12th, Washington, 1977.

Proceedings of the 12th Intersociety Energy Conversion Engineering Conference, Washington, D. C., August 28 through September 2, 1977. — La Grange, Ill. :

779157 — Compressed Air Energy Storage for Electric Utility Load Leveling, K. G. Vosburgh, D. C. Golibersuch, P. M. Jarvis, J. A. Bast, J. H. Eskesen, General Electric Co., Schenectady, N.Y.; A. S. Mitchell, Fenix & Scisson, Inc.; E. J. Sosnowicz, United Eng. & Const.; S. Serata, Serata Geomechanics; J. Pepper, EFRI

2)

1016

779158 — Compressed Air Storage for Load Leveling of Nuclear Power Plants, Z. S. Stys, Brown Boveri Corp., N. Brunswick, N.J.

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78A33120 ISSUE 13 PAGE 2391 CATEGORY 44  
77/00/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Heat transfer effects in compressed air energy storage  
AUTH: A/VOSBURGH, K. G.; B/KOSKY, P. G. PAA: A/(General Electric Co., Schenectady, N.Y.); B/(Lehigh University, Bethlehem, Pa.)

In: Heat transfer in energy conservation; Proceedings of the Winter Annual Meeting, Atlanta, Ga., November 27-December 2, 1977. Meeting sponsored by the American Society of Mechanical Engineers, New York, American Society of Mechanical Engineers, 1977, p. 83-90. Research supported by the Electric Power Research Institute.

MAJS: /\*COMPRESSED AIR/\*ENERGY STORAGE/\*HEAT TRANSFER/\*  
UNDERGROUND STORAGE

MINS: / ENERGY REQUIREMENTS/ ENERGY TECHNOLOGY/ FINITE  
DIFFERENCE THEORY/ MINES (EXCAVATIONS)/ SALTS/ SYSTEMS  
ENGINEERING/ THERMAL STRESSES

ABA: (Author)

ABS: Compressed-air energy-storage (CAES) systems are being developed for peak-load-leveling applications by electric utilities. Energy is stored by compressing air in an underground cavern; when power is required, the air is heated and expanded through a turbine-generator system. This work is part of a conceptual design of an 800-MW CAES system which uses a set of storage cavities mined in salt. Each storage cavern forms a constant-volume reservoir; thus, the storage pressure and temperature vary over the weekly cycle. The thermal properties of the air and the salt region surrounding the cavern were simulated using a finite-difference approach. The cavern surface temperature shows a wide variation over the weekly cycle, although this is damped out several meters from the wall. The walls act to cool the air at high temperature, but to heat at low temperature. Detailed examples of this effect are presented along with an analysis of optimal air-injection conditions to maximize storage of energy while avoiding excessive thermal stress.

77A48770 ISSUE 23 PAGE 3984 CATEGORY 44  
77/00/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Conceptual design of underground compressed air  
storage electric power systems

AUTH: A/GIRAMONTI, A. J.; B/LESSARD, R. D.; C/HOBSON, M. J. PAA: B/(United Technologies Research Center, East Hartford, Conn.); C/(Acres American, Inc., Buffalo, N.Y.)

In: Intersociety Energy Conversion Engineering Conference, 12th, Washington, D.C., August 28-September 2, 1977. Proceedings, Volume 1. (A77-48701 23-44) La Grange Park, Ill.: American Nuclear Society, Inc., 1977, p. 591-598.

ABA: (Author)

ABS: Conceptual design studies have been conducted to identify Compressed Air Energy Storage (CAES) systems which are potentially attractive for future electric utility load-leveling applications. The CAES concept consists of compressing air during off-peak periods, underground storage, followed by heating and expansion through turbines to generate power. By using off-peak electricity for compression and stored air for peak-load generation, the resulting oil consumption would be about 40 percent of that consumed by conventional peaking plants. Equipment requirements could be met using existing turbomachinery with relatively modest modifications. The present study focused on air storage in hydraulically compensated hard-rock caverns. Conventional underground excavation technology could be used to construct these caverns, and sufficient siting opportunities exist in the North Central and Northeast regions of the U.S.

N77-31864 Idaho Univ., Moscow. Dept. of Civil Engineering.

PUMPED STORAGE POTENTIAL OF THE HELL'S CANYON AREA M.S. Thesis

Larry Douglas Coupe Apr. 1977 143 p. refs

(Contract DI-14-31-0001-5070: OWRT Proj. B-037-IDA(1))

(PB-267722/7; W77-08196) Avail: NTIS HC A07/MF A01  
CSCL 10B

The potential for pumped storage hydroelectric development of the Hells Canyon area is reviewed with conclusions drawn from preliminary investigation. Background information covers the concept and application of pumped storage. Hells Canyon's physical characteristics and history and its status as a National Recreation Area. Of eighteen potential storage sites noted, the three most promising are analyzed in detail. For each, preliminary designs were developed as well as computer analyses of the reservoir water level fluctuations that could result from such operations. Each is also analyzed for economic feasibility. Conclusions are that pumped storage in the area is too expensive to be competitive now, but it may be more feasible in the future.

GRA



78A12221 ISSUE 2 PAGE 251 CATEGORY 44 77/11/00  
3 PAGES UNCLASSIFIED DOCUMENT

UTTL: Underground hydroelectric pumped storage - A practical option

AUTH: A/SCOTT, F. M. FAA: A/(Harza Engineering Co., Chicago, Ill.)

Energy, vol. 2, Fall 1977, p. 20-22.

MAJS: /\*ENERGY STORAGE/\*HYDROELECTRIC POWER STATION/\* UNDERGROUND STORAGE

MINS: / COST ESTIMATES/ ENERGY REQUIREMENTS/ ENERGY TECHNOLOGY/ TURBINE PUMPS

ABA: G.R.

ABS: It is pointed out that hydroelectric pumped storage is, perhaps, currently the only practical or demonstrated means to store energy economically in significant quantities. In the case of conventional pumped storage projects, there are often problems related to the distance between suitable storage sites and the higher load centers. However, underground pumped storage facilities can be built in many areas near load centers, and they require far less land surface as heads up to 4,400 to 4,800 feet can be utilized. The design and the operational

characteristics of such underground facilities are illustrated with the aid of examples involving three alternative arrangements. Attention is given to the mechanical equipment, the power station arrangement, the time required for construction, and project construction costs. In one case, energy can be stored at an estimated cost of \$270 per kilowatt.

77N33636# ISSUE 24 PAGE 3240 CATEGORY 44 RPT#:  
CONS/NSF/42-1 CNT# NSP AER-74-00242 76/12/00 2  
VOLS 318 PAGES UNCLASSIFIED DOCUMENT

UTTL: Preliminary feasibility evaluation of compressed air storage power systems, volume 1 TLSP: Final Report, Jun. 1975 - Dec. 1976

CORP: United Technologies Research Center, East Hartford, Conn. AVAIL:NTIS SAP: HC A14/MF A01  
Sponsored in part by ERDA

MAJS: /\*COMPRESSED AIR/\*ENERGY STORAGE/\*FEASIBILITY ANALYSIS

MINS: / ECONOMIC FACTORS/ ENVIRONMENT EFFECTS/ GAS TURBINES

ABA: ERA

ABS: A preliminary technical, economic, and environmental feasibility evaluation of generating peak power with a compressed air power system incorporating a modified state-of-the-art gas turbine and an hydraulically compensated, mined, hard rock cavern was conducted. Results are presented covering the siting potential and economics for hard rock storage caverns, the types of aboveground equipment which could be used with suitable modifications, system performance and economics, and the potential for electric utility application. The technical approach was based on technology currently available, although in some cases not yet reduced to commercial practice.

78A28591 ISSUE 11 PAGE 2000 CATEGORY 44  
77/00/00 10 PAGES In GERMAN UNCLASSIFIED DOCUMENT

UTTL: Direct utilization of solar energy with the aid of low-temperature heating

AUTH: A/BACH, H. PAA: A/(Stuttgart, Universitaet, Stuttgart, West Germany)

In: Heating with the sun II - Principles of solar technology: Meeting, 3rd, Munich, West Germany, March 3, 4, 1977. Report, Volume 2. (A78-28576 11-44)  
Munich, Deutsche Gesellschaft fuer Sonnenenergie, 1977, p. 271-280. In German.

MAJS: /\*HEAT STORAGE/\*LOW TEMPERATURE/\*SOLAR ENERGY/\*SOLAR HEATING

MINS: / ENERGY REQUIREMENTS/ HEAT PUMPS/ HEAT TRANSFER/ SOLAR ARRAYS/ SOLAR COLLECTORS/ SOLAR HOUSES/ WORKING FLUIDS

ABA: B.U.

ABS: Direct solar heating of houses precludes the use of any energy sources but the sun as well as the use of heat pumps to raise the temperature of the heat-transfer fluid. The major components of the system, used here for low-temperature heating, are a solar-collector array, a heat-storage unit and the working fluid. In designing a low-temperature-heating solar house, consideration is given to month-by-month yearly heat requirements and to the optimal type of solar collector.

#### Pumped Storage Potential of the Hell's Canyon Area.

Larry Douglas Coupe.

Idaho Univ., Moscow, Dept. of Civil Engineering. Apr 77, 143p W77-08196, OWRT-B-037-IDA(1)

PB-267 722/7WE Price code: PC A67/MF A01

The potential for pumped storage hydroelectric development of the Hells Canyon area is reviewed, with conclusions drawn from preliminary investigation. Background information covers the concept and application of pumped storage, Hells Canyon's physical characteristics and history and its status as a National Recreation Area. Of eighteen potential storage sites noted, the three most promising are analyzed in detail. For each, preliminary designs have been developed as well as computer analyses of the reservoir water level fluctuations that would result from such operations. Each is also analyzed for economic feasibility. Conclusions are that pumped storage in the area is too expensive to be competitive now, but it may be

TJ Energy development III / sponsored by the IEEE  
 153 Energy Development Subcommittee of the IEEE  
 .E4783 Power Generation Committee of the IEEE Power  
 nt.3 Engineering Society. — New York : Institute  
 of Electrical and Electronics Engineers,  
 cl977.  
 178 p. : ill. ; 28 cm. — (IEEE Power  
 Engineering Society Papers ; 3)  
 "7XCH1215-3-PWR"

Air Storage System Energy Transfer (ASSET) Plants - A Utility's Evaluation,  
 by Robert Beckwith and Z. Stanley Stys.....*p. 115*.....

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Offshore and underground power plants.  
 Robert Noyes, Ed.  
 Noyes Data Corp. 1977.

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## ENERGY STORAGE - FLYWHEELS

79A51788 ISSUE 23 PAGE 4373 CATEGORY 44  
79/00/00 5 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Low cost flywheel energy storage system demonstration  
AUTH: A/RABENHORST, D. W. PAA: A/(Johns Hopkins  
University, Laurel, Md.)  
In: Intersociety Energy Conversion Engineering  
Conference, 14th, Boston, Mass., August 5-10, 1979,  
Proceedings, Volume 1. (A79-51726 23-44) Washington,  
D.C.: American Chemical Society, 1979, p. 374-378.  
MAJS: /\*ENERGY STORAGE/\*FLYWHEELS/\*LOW COST/\*SYSTEM  
EFFECTIVENESS  
MINS: / BEARINGS/ ENERGY DISSIPATION/ ENERGY TECHNOLOGY/  
FABRICATION/ GLASS FIBER REINFORCED PLASTICS/ MAGNETIC  
MATERIALS  
ABA: A.T.  
ABS: This paper presents a description of the low cost  
flywheel energy storage system demonstration program.  
The applicable flywheel configurations including  
pseudo-isotropic and bare filament, low cost materials  
such as steel wire and vinyl-impregnated fiberglass,  
low loss, long life bearing investigations, and the  
flywheel energy storage demonstration units, were  
described. It was concluded that a very low flywheel  
production cost of \$50 per kW-hr can be achieved with  
several materials, the filament configuration is best,  
magnetically load-relieved mechanical bearings are  
promising for the low cost, long life system, and a  
flywheel energy storage system is feasible for home  
applications.

BOA12166 ISSUE 2 PAGE 245 CATEGORY 44 79/11/00  
9 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Flywheels for energy storage  
AUTH: A/MILLNER, A. R. PAA: A/(MIT, Lexington, Mass.)  
Technology Review, vol. 82, Nov. 1979, p. 32-40.

ABA: A.L.W.  
ABS: Flywheels are considered as an economical means of  
storing energy generated by solar and wind power  
systems and electric utilities when demand is low  
until the demand is high. The structural failure modes  
of flywheel materials are examined, noting the  
favorable characteristics of anisotropic wound fiber  
or fiber composite construction, and estimates of  
rotor size on the order of one ton for domestic  
applications (40 kWh storage capacity) are presented.  
Magnetic bearings are proposed as means of eliminating  
rotor drag in a vacuum environment while drawing only  
a small current and being capable of operating for at  
least 20 to 30 years. The design of motor-generators  
to convert electrical energy to mechanical energy and  
back again is examined, and brushless magnetic  
motor-generators are discussed. Cost comparisons show  
that flywheel storage could be cost-competitive with  
battery systems over a 20-year lifetime.

79A33246# ISSUE 13 PAGE 240B CATEGORY 44  
79/00/00 13 PAGES In PORTUGUESE UNCLASSIFIED  
DOCUMENT  
UTTL: Design of a mechanical energy storage unit ---  
flywheel  
AUTH: A/NETO, F. P. L.; B/DE ALBUQUERQUE ROSA, C. PAA:  
B/(Campinas, Universidade Federal, Campinas, Sao  
Paulo, Brazil)  
In: Brazilian Conference on Energy, 1st, Rio de  
Janeiro, Brazil, December 12-14, 1978, Proceedings,  
Volume B. (A79-33212 13-44) Rio de Janeiro,  
Universidade Federal do Rio de Janeiro, 1979, p.  
488-500. In Portuguese.  
MAJS: /\*ENERGY STORAGE/\*FLYWHEELS/\*MECHANICAL ENGINEERING/\*  
ROTATING DISKS  
MINS: / COMPOSITE STRUCTURES/ ENERGY TECHNOLOGY/ STEELS/  
STRESS CONCENTRATION/ VACUUM CHAMBERS  
ABA: (Author)  
ABS: The purpose of this paper is to present the design of  
a mechanical energy storage unit. The stored energy  
capacity is analyzed in function of the material and  
the profile of the flywheel. The construction of  
flywheel consisting of steel disks spinning in a  
vacuum chamber is presented.



BON12553# ISSUE 3 PAGE 353 CATEGORY 44 RPT#:  
AD-A071242 FJSRL-TR-79-1006 CNT# AF PROJ. 2303  
79/05/00 47 PAGES UNCLASSIFIED DOCUMENT

UTTL: The USAF Academy flywheel-electric car preliminary design report TLSP: Progress Report, 1 Oct. 1977 - 31 May 1979

AUTH: A/RATCLIFF, D. D.

CORP: Air Force Academy, Colo. CSS: (Research Lab.)  
AVAIL NTIS SAP: HC A03/MF A01

MAJS: /\*ELECTRIC MOTOR VEHICLES/\*ENERGY STORAGE/\*ENERGY TECHNOLOGY/\*FLYWHEELS

MINS: / AIR POLLUTION/ PERFORMANCE/ STORAGE BATTERIES/ TRANSMISSIONS (MACHINE ELEMENTS)

ABA: GRA

ABS: Although problems caused by pollution and declining petroleum reserves have caused renewed interest in electric vehicles, currently-available lead-acid batteries impose performance limitations which are unacceptable to most drivers. These limitations, specifically low range and acceleration, are greatly improved by the addition of a flywheel and continuously-variable transmission to the power train of the electric vehicle. This paper describes a low-technology flywheel-electric car built by U.S. Air Force Academy cadets and faculty members in the Department of Physics under funding provided by Frank J. Sellar Research Laboratory. The car design discussed appears to offer the possibility for a four-passenger urban vehicle with a range of 70-100 miles and acceleration performance comparable to that of current sub-compact cars. This performance is achieved with a simple driving system which is comparable to that in current automatic transmission cars. The paper also details the benefits and problems resulting from the low-technology design chosen and provides trade-off analyses on some of the specific problems inherent in the use of a flywheel in the power train of a vehicle. Finally, the paper suggests future improvements which could lower the weight of the vehicle, make the transmission shifting more precise, and improve the performance of the car on grades.

79A51783 ISSUE 23 PAGE 4372 CATEGORY 44 CNT#:  
EY-76 C-02-4010 79/00/00 9 PAGES UNCLASSIFIED DOCUMENT

JTTL: Regenerative flywheel energy storage system

AUTH: A/LUSTENADER, E. L.; B/EDELFELT, I. H.; C/JONES, D. W.; D/PLUNKETT, A. B.; E/RICHTER, E.; F/TURNBULL, F. G. PAA: F/(General Electric Co., Schenectady, N.Y.)

In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 343-351

ABA: (Author)

ABS: This paper describes the status of a program to develop and evaluate a regenerative flywheel energy storage system. The system has been designed for a battery/flywheel electric vehicle in the 3000 pound class. Laboratory tests will simulate this electric vehicle operating over the SAE J227a Schedule D driving cycle. The range improvement attributed to the use of the flywheel will be established. The flywheel energy storage system will consist of a solid rotor, synchronous inductor-type flywheel drive machine electrically coupled to a DC battery electric propulsion system through a load commutated inverter. The motor/alternator unit is coupled mechanically to a small steel flywheel which provides a portion of the vehicle's accelerating energy and regenerates the vehicle's braking energy. The laboratory simulation will include a battery bank, propulsion motor coupled to a flywheel and the flywheel energy storage system comprised of the water/flywheel unit, the load commutated inverter and its control.

79A51996 ISSUE 23 PAGE 4386 CATEGORY 44  
79/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Ball screw type wave power generator --- with flywheel drive

AUTH: A/OHMATA, K.-I.; B/SHIMODA, H. PAA: B/(Zeiji University, Kawasaki, Japan)

In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 2. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 1940-1951.

MAJS: /\*COMPUTERIZED SIMULATION/\*ELECTRIC GENERATOR/\*FLYWHEELS/\*WATERWAVE ENERGY CONVERSION

MINS: / ENERGY TECHNOLOGY/ GRAPHS (CHARTS)/ MECHANICAL ENGINEERING/ TABLES (DATA)

ABA: (Author)

ABS: To obtain an even flow of electric power from fluctuating wave energy, the authors devised a ball screw type wave power generator (BSTWPG) which consists of a pressure plate, ball screws and nuts, one-way clutches, flywheels and generators. The equations of motion of the BSTWPG system are shown and the digital simulation using Continuous System Simulation Language is developed on the assumption that the wave force is sinusoidal. The experimental model is composed of a ball screw of outside diameter 22 mm and a flywheel having moment of inertia of 2.5 kgf sq s cm. When this model was subjected to the sinusoidal motion of amplitude 17 mm and frequency 0.7 Hz by a vibration table, six 6 volts - 6 watts bulbs were lighted up. In this case, the rotating speed of the flywheel changed within the range of 490-590 rpm.



# WHIRL DYNAMICS OF PENDULOUS FLYWHEELS USING BOND GRAPHS

Mont Hubbard

Journal of the Franklin Institute, vol 308, no. 4, Oct. 1979, pp. 405-421.

**ABSTRACT:** Bond graphs are used to generate the equations of motion of a whirling flywheel. The formulation is shown to be a natural one when control forces and moments are included for active control of the whirling modes. Critical frequencies are interpreted as rotational speeds at which non-zero equilibrium configurations exist for displacements (as opposed to the more familiar momenta) and arise when the system dynamics matrix of the complete whirl motion has two zero eigenvalues. In addition, oscillatory modes corresponding to non-zero eigenvalues are examined. Time simulations and other numerical results are given for an example flywheel system which has been proposed for electric utility energy storage.

79A51821 ISSUE 23 PAGE 4376 CATEGORY 44  
79/00/00 5 PAGES UNCLASSIFIED DOCUMENT

**UTTL:** Advanced flywheel energy storage unit for a high power energy source for vehicular use

**AUTH:** A/RAYNARD, A. E. PAA: A/(AiResearch Manufacturing Company of California, Torrance, Calif.)  
In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 622-626.

**MAJS:** /\*ENERGY STORAGE/\*FLYWHEELS/\*SURFACE VEHICLES/\*TRANSPORTATION ENERGY

**MINS:** / COOLING SYSTEMS/ ELECTRIC MOTOR VEHICLES/ ENERGY TECHNOLOGY/ LUBRICATION SYSTEMS/ POWER EFFICIENCY

**ABA:** M.E.P.

**ABS:** The design and development program of a flywheel energy storage unit (ESU) for vehicular use are surveyed. Attention is given to the fabrication and experimental determination of the performance of an advanced hermetically sealed ESU that has been sized for a typical 3000 pound curb weight vehicle. The flywheel can supply high power demands and can accept vehicle kinetic energy during braking (regeneration) at a rate limited only by the transmission power capability. It is noted that the principal goal of the development program is to provide decision making information regarding the benefits of a mechanical energy storage device, as it applies to vehicle fuel consumption or vehicle range. Finally, the testing and evaluation subtasks of the development program are covered.

79A51784 ISSUE 23 PAGE 4373 CATEGORY 44  
79/00/00 5 PAGES UNCLASSIFIED DOCUMENT

**UTTL:** High-energy-density flywheel --- rotor design and fabrication

**AUTH:** A/SATCHWELL, D. L. PAA: A/(AiResearch Manufacturing Company of California, Torrance, Calif.)  
In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings, Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 352-356.  
Research supported by the U.S. Department of Energy.

**MAJS:** /\*FLYWHEELS/\*GRAPHITE-EPOXY COMPOSITE MATERIALS/\*HUBS/\*STRUCTURAL DESIGN

**MINS:** / BENDING FATIGUE/ COMPRESSION TESTS/ COST ANALYSIS/ ENERGY STORAGE/ ENERGY TECHNOLOGY/ FABRICATION/ FLUX DENSITY/ KEVLAR (TRADEMARK)/ POTORS/ SHEAR STRESS

**ABA:** A.T.

**ABS:** The design and fabrication of a flywheel rotor with an energy density of 80 w-hr/kg is described. The design uses a multi-ring, S-glass and Kevlar composite rim mounted on a graphite composite spoked hub. Graphite composite material reduces the rotor assembly weight, increasing the energy density, and graphite-epoxy material was selected for the hub because of its high modulus of elasticity, light weight, and high ultimate flexural strength. The hub consists of multiple slats alternately bonded together to form a four-spoke hub of rigid cruciform shape. Hubs were compression tested and two hubs were cycled to an increased stress level equivalent to a full-life test.

80N11594# ISSUE 2 PAGE 220 CATEGORY 44 RPT#:  
UCRL-13982 CNT# W-7405-ENG-48 79/00/00 30 PAGES  
UNCLASSIFIED DOCUMENT

**UTTL:** Regenerative flywheel energy storage system

**AUTH:** A/LUSTENADER, E. L.; B/EDELFEIT, I. H.; C/JONES, D. W.; D/PLUNKETT, A. B.; E/RICHTER, E.; F/TURNBULL, F. G.

**CORP:** General Electric Co., Schenectady, N. Y. CSS: (Corporate Research and Development Dept.)  
AVAIL NTIS SAP: HC A03/MF AG1

**MAJS:** /\*ELECTRIC BATTERIES/\*ENERGY STORAGE/\*ENERGY TECHNOLOGY/\*FLYWHEELS

**MINS:** / DIRECT CURRENT/ ELECTRIC MOTOR VEHICLES/ REGENERATION (ENGINEERING)/ ROTORS

**ABA:** DOE

**ABS:** The current status of a program to develop and evaluate a regenerative flywheel energy storage system is described. The system was designed for a battery/flywheel electric vehicle in the 3000 pound class.

79A51792 ISSUE 23 PAGE 4373 CATEGORY 44  
79/00/00 4 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Residential flywheel with turbine supply  
AUTH: A/PLACE, T. W. PAA: A/(AirResearch Manufacturing  
Company of California, Torrance, Calif.)  
In: Intersociety Energy Conversion Engineering  
Conference, 14th, Boston, Mass., August 5-10, 1979.  
Proceedings, Volume 1. (A79-51726 23-44) Washington,  
D.C., American Chemical Society, 1979, p. 395-398.

MAJS: /\*DOMESTIC ENERGY/\*ENERGY STORAGE/\*FLYWHEELS/\*  
WINDPOWERED GENERATORS  
MINS: / CLEAN ENERGY/ COST EFFECTIVENESS/ ENERGY TECHNOLOGY/  
RESEARCH PROJECTS/ TURBINES  
ABA: (Author)  
ABS: A flywheel system that stores energy from a wind  
turbine source and converts the energy to a 60-Hz,  
220-V output for residential use is described. The  
typical residence has a 1500-sq ft floor area, with a  
maximum power level of 5 kW. The flywheel system was  
defined in a study to determine the cost benefits of  
storing wind energy in a flywheel and using it on a  
demand basis. The systems and the flywheel rotor  
materials that offer the greatest promise in reducing  
initial costs were examined. The paper describes the  
progress to date on this program and the work planned  
to complete the study.

79A51789 ISSUE 23 PAGE 4373 CATEGORY 44  
79/00/00 4 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Novel flywheel energy storage system  
AUTH: A/CHICUREL, R. PAA: A/(Universidad Nacional Autonoma  
de Mexico, Mexico City, Mexico)  
In: Intersociety Energy Conversion Engineering  
Conference, 14th, Boston, Mass., August 5-10, 1979.  
Proceedings, Volume 1. (A79-51726 23-44) Washington,  
D.C., American Chemical Society, 1979, p. 379-382.  
MAJS: /\*ENERGY STORAGE/\*FLYWHEELS/\*KINETIC ENERGY  
MINS: / CLEAN ENERGY/ DESIGN ANALYSIS/ ENERGY TECHNOLOGY/  
MECHANICAL DRIVES  
ABA: (Author)  
ABS: This report describes a kinetic energy storage system  
in which a flywheel rotates inside an evacuated  
casing. Both the flywheel and the casing rotate about  
a horizontal axis, but the speed of the second is much  
lower than that of the first. This is governed by a  
fixed ratio mechanical drive also contained within the  
casing itself. The reaction torque required by the  
drive is provided by the action of gravity on a  
reaction member which is mounted in the manner of a  
pendulum. Three versions of the system are proposed. A  
prototype of one of these with a capacity of 25  
watt-hours is being built.

80N15635# ISSUE 6 PAGE 767 CATEGORY 44 RPT#:  
COO-4094-48 CONF-790515-4 CNT#: EY-76-C-02-4094  
79/00/00 15 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Flywheel energy storage and conversion system for  
photovoltaic applications  
AUTH: A/MILLNER, A. R.  
CORP: Lincoln Lab., Mass. Inst. of Tech., Lexington.  
AVAIL.NTIS SAP: HC A02/MF A01  
Presented at the Intern. Assembly on Energy Storage,  
Dubrovnik, Yugoslavia, 2 May 1979  
MAJS: /\*ENERGY CONVERSION/\*ENERGY STORAGE/\*FLYWHEELS/\*  
PHOTOVOLTAIC CELLS/\*SYSTEMS ENGINEERING  
MINS: / ARMATURES/ BEARINGS/ ELECTRIC MOTORS/ INVERTED  
CONVERTERS (DC TO AC)/ SOLAR ARRAYS  
ABA: DOE  
ABS: The design of a flywheel energy storage and conversion  
system is examined. The system serves as an interface  
between a solar photovoltaic array and an ac load,  
providing output waveform regulation as well as energy  
storage. Characteristics of the system include  
magnetic bearings, an ironless armature motor  
generator, and a low cost flywheel rotor. An economic  
analysis is presented.

79N26528# ISSUE 17 PAGE 2284 CATEGORY 44 RPT#:  
SAND-79-0001 CNT#: EY-76-C-04-0789 79/01/00 150  
PAGES UNCLASSIFIED DOCUMENT  
UTTL: Proceedings of the Workshop on Mechanical Storage of  
Wind Energy  
CORP: Sandia Labs., Albuquerque, N. Mex. AVAIL.NTIS  
SAP: HC A07/MF A01  
Workshop held at Albuquerque, N. Mex., 14 Dec. 1978  
MAJS: /\*CONFERENCES/\*ENERGY STORAGE/\*WIND (METEOROLOGY)  
MINS: / COMPUTERIZED SIMULATION/ ENERGY CONVERSION/  
FLYWHEELS/ MANAGEMENT SYSTEMS/ MECHANICAL ENGINEERING/  
POWER CONDITIONING/ SYSTEMS ANALYSIS  
ABA: DOE  
ABS: Information is summarized on (1) flywheel interface  
and storage technology for photovoltaic applications;  
(2) a simulation model for wind energy systems; (3)  
planned FY 79 SERI tasks in storage and wind; (4)  
energy storage technology development to support the  
DOE wind energy program; (5) wind energy conversion  
system storage needs; (6) energy conversion and  
storage; and (7) SLA systems analysis results.

**N80 10639#** Lincoln Lab., Mass. Inst. of Tech., Lexington.  
**FLYWHEEL ENERGY STORAGE AND CONVERSION  
SYSTEM FOR SOLAR PHOTOVOLTAIC APPLICATIONS**  
Alan R. Millner 1979 9 p. Presented at the ASME Gas  
Turbine Conf., San Diego, Calif., 12-15 Mar. 1979  
(Contract EY-76-C-02 4094)  
(COO-4094-31) Conf 790305 6) Avail NTIS  
HC A02/MF A01

A low-drag, low-power magnetic bearing and a permanent magnet brushless DC motor-generator developed were developed for a satellite flywheel. These will be combined with a terrestrial flywheel and control electronics to make up a flywheel energy storage and conversion system for use in a stand-alone solar photovoltaic residence. Technical and economic performance analyses indicate that, contrary to general thought, a flywheel system will be competitive if not superior to more conventional systems utilizing either present day or advanced batteries. This derives from the ability of the flywheel to perform the functions of dc-to-ac inversion and optimal impedance matching between the PV arrays and the load in addition to providing energy storage. The structural topology, performance data, design parameters, and test measurements of the magnetic bearing and motor-generator are to be used as well as the flywheel and control electronics. A preliminary discussion of the economic aspects is also included. DOE

#### AN INTRODUCTION TO THE VARIABLE INERTIA FLYWHEEL (VIF) D. Ullman, H. Velkoff.

Transactions of the ASME  
Journal of Applied Mechanics, vol 46, no 1, March 1979  
p.186-190.

*A flywheel with variable moment of inertia, combining the functions of energy storage and power control is introduced. Potential designs are presented and the basic physical governing equations developed. Examples of the flywheel system powering a constant angular rate, frictional load, and an accelerating automobile are presented. Limitations of and potential for future development which become evident in the examples are discussed.*

**N80-11594#** General Electric Co., Schenectady, N. Y. Corporate  
Research and Development Dept.  
**REGENERATIVE FLYWHEEL ENERGY STORAGE SYSTEM**  
E. L. Lustenader, I. H. Edelfelt, D. W. Jones, A. B. Plunkett, E.  
Richter, and F. G. Turnbull 1979 30 p. refs  
(Contract W-7405-eng-48)  
(UCRL-13982) Avail: NTIS HC A03/MF A01  
The current status of a program to develop and evaluate a  
regenerative flywheel energy storage system is described. The  
system was designed for a battery/flywheel electric vehicle in  
the 3000 pound class. DOE

**COMPOSITE-RIM FLYWHEELS: SPIN TESTS.** E.D. Reedy Jr.  
and H.K. Street.

Sampe Quarterly, vol 10, no 3, April 1979, p. 36-41.

Two composite-rim flywheels of a size appropriate for use in a hybrid vehicle were designed. Each design employed a different method of utilizing Kevlar 49/epoxy bands to attach the rim to an aluminum hub. Four prototype flywheels, two of each design, have been fabricated and spin tested.

**BASEMENT FLYWHEEL STORES SOLAR ENERGY AT 15,000 RPM.**  
Susan Renner-Smith.

Popular Science, vol 215, no 4, October 1979.  
p. 76-78.

Better than batteries? Flywheels may be - at least in  
storing random bursts of energy from sun and wind.

**FLYWHEELS FOR ENERGY STORAGE.** A. R. Millner.

Technology Review, vol 82, no 2, November 1979,  
p. 32-41.

Flywheels may be  
economically superior  
to chemical batteries  
for storing energy in  
solar- and wind-  
power systems and  
for peak load shaving  
on electric utility  
systems.



**N80-15609#** Lincoln Lab., Mass. Inst. of Tech., Lexington  
**FLYWHEEL ENERGY STORAGE INTERFACE UNIT FOR PHOTOVOLTAIC APPLICATIONS**

A. R. Millner and R. D. Hay 1979 6 p refs Presented at the Intersociety Energy Conf., Boston 5 Aug 1979 (Contract EY-76-C-02-4094)  
(COO-4094-44; CONF-790803-42) Avail: NTIS HC A02/MF A01

The design of a flywheel energy storage and conversion system is presented. The system which will serve as an interface between a solar photovoltaic array and an ac load, providing output waveform regulation as well as energy storage is evaluated. Features of the system include magnetic bearings, an ironless armature motor generator, and a low cost flywheel rotor. A preliminary economic analysis is provided. DOE

**A80-12166** Flywheels for energy storage. A. R. Millner (MIT, Lexington, Mass.). *Technology Review*, vol. 82, Nov. 1979, p. 32-40. 8 refs.

Flywheels are considered as an economical means of storing energy generated by solar and wind power systems and electric utilities when demand is low until the demand is high. The structural failure modes of flywheel materials are examined, noting the favorable characteristics of anisotropic wound fiber or fiber composite construction, and estimates of rotor size on the order of one ton for domestic applications (40 kWh storage capacity) are presented. Magnetic bearings are proposed as means of eliminating rotor drag in a vacuum environment while drawing only a small current and being capable of operating for at least 20 to 30 years. The design of motor-generators to convert electrical energy to mechanical energy and back again is examined, and brushless magnetic motor-generators are discussed. Cost comparisons show that flywheel storage could be cost competitive with battery systems over a 20-year lifetime. A.L.W.

**FLYWHEEL CUTS BUS FUEL USE 50%.** Irwin Stambler.

Industrial Research/Development, October, 1979  
p. 62-64.

**N79-29665#** California Univ., Livermore. Lawrence Livermore Lab.

**DOE/STOR BIBLIOGRAPHY FOR FLYWHEEL ENERGY SYSTEMS, 1977**

B. Mallon and R. W. Kuhn 5 Jan. 1979 330 p  
(Contract W-7405-eng-48)  
(UCRL-52637) Avail: NTIS HC A15/MF A01

Five hundred and fifty-five selected references to the world literature through December 1977 are presented. It includes citations that describe flywheel designs, properties and materials, and the actual and contemplated applications of flywheels in vehicles, utilities, aircraft, and spacecraft. The citations are selectively grouped according to the subjects mentioned above and organized by author and by date. An alphabetical index of authors is presented as well as a listing of keyphrases organized by subject matter. An alphabetical listing of authors and keyphrases are reported. DOE

**COMPOSITE-RIM FLYWHEELS: SPIN TESTS,** E. D. Reedy, Jr. and H. K. Street

*SAMPE Quarterly*, v.10, no.3, Apr. 1979, p.36-

Two composite-rim flywheels of a size appropriate for use in a hybrid vehicle were designed. Each design employed a different method of utilizing kevlar 49/epoxy bands to attach the rim to an aluminum hub. Four prototype flywheels two of each design, have been fabricated and spin tested.

**N79-11550#** National Technical Information Service, Springfield, Va

**DESIGN AND APPLICATIONS OF FLYWHEELS. CITATIONS FROM THE NTIS DATA BASE Progress Report, 1964 - Aug. 1978**

Guy E. Habercom, Jr. Sep. 1978 263 p Supersedes NTIS/PS-77/0882; NTIS/PS-76/0767; NTIS/PS-75/743; NTIS/PS-75/070  
(NTIS/PS-78/0997/3; NTIS/PS-77/0882; NTIS/PS-76/0767; NTIS/PS-75/743; NTIS/PS-75/070) Avail: NTIS HC \$28.00/MF \$28.00 CSCL 131

The design and varied applications of flywheels and reaction wheels are investigated. Such diversified applications as satellite stabilization, surface vehicle propulsion, energy transfer devices, and inertial or friction welding are reviewed. This updated bibliography contains 258 abstracts, 74 of which are new entries to the previous edition. GRA



**A79-20852** Composite material flywheels for energy storage on electricity supply systems. P. J. Worthington (Central Electricity Generating Board, Research Laboratories, Leatherhead, Surrey, England). In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 846-855. 12 refs.

The paper assesses the use of composite-material flywheels for large-scale storage of electricity. To achieve useful storage of about 10 MWh, large composite-material components need to be constructed and supported, and ancillary equipment developed to extract power from the flywheels. In particular, the costs of this method of storage are considered in order to evaluate the economic aspect of composite flywheels. A curve for useful energy stored vs flywheel mass is presented for different materials - Kevlar/epoxy, carbon/epoxy, glass/epoxy (all with about 60 vol% fiber) and steel. Another curve for tension/tension fatigue properties of unidirectional composites, with about 60 vol% fiber is given. Both a radially thin hoop wound rim and rods of aligned fibers mounted in a sweep's brush configuration for composite flywheel construction are discussed. S.D.

**A79-20853** Current status of composite flywheel development. R. H. Toland (California, University, Livermore, Calif.). In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 856-876. 24 refs. Contract No. W-7405-eng-48.

The paper surveys the recent developments in the applications of fiber composite materials to flywheel energy storage systems. The impact of these materials on flywheel energy storage is discussed in relation to transportation systems, specifically the performance requirements and the effect of system constraints on the ultimate effectiveness of the composite rotors. General flywheel design concepts are discussed in light of several performance criteria and the inherent design and material limitations, including those affecting reliability and life. Specific composite rotors that have been built and tested are discussed in terms of their demonstrated performance and are assessed for their potential. Also, recent government-sponsored research and development programs are briefly reviewed, and recommendations are made for future work. (Author)

78N31529 ISSUE 22 PAGE 2959 CATEGORY 44  
78/00/00 216 PAGES UNCLASSIFIED DOCUMENT  
UTTL: A variable inertia flywheel as an energy storage system TLSP: Ph.D. Thesis  
AUTH: A/ULLMAN, D. G.  
CORP: Ohio State Univ., Columbus. SAP: Avail: Univ.  
Microfilms Order No. 7812395

# KINETIC ENERGY/ VARIABILITY

ABA: Dissert. Abstr.

ABS: A variable inertia flywheel (VIF) system was designed and fabricated to verify theoretical predictions and to evaluate the basic operating characteristics of the concept. A fully controllable VIF, full control over the moment of inertia irrespective of the VIF state, is not practical as the efficiency obtained can be no better than a fixed inertia flywheel with an infinitely variable ratio transmission. However, a VIF with a fixed power recirculation results in a flywheel with a unique torque/angular rate characteristic. A VIF can theoretically be formed such that the torque is related to any function of angular rate.

**N78-30834/** Engines Matra, Vélizy (France). Automatisme Dept.

**STUDY OF SYSTEM IMPLICATIONS OF HIGH SPEED FLYWHEELS AS ENERGY STORAGE DEVICES ON SATELLITES, VOLUME 1 Final Report**

H. Nghia Nguyen and Francois Mariau Oct. 1978 68 p refs 2 Vol.

(Contract ESA-3261/77/NL-AK)

(Rept-30/1020-Vol-1; ESA-CR(P)-1168-Vol-1) Avail: NTIS HC A04/MF A01

The feasibility of integrated energy storage and attitude control systems using high speed flywheels is demonstrated. The impact of magnetic bearing technologies on these flywheel applications is assessed. The flywheel designs for different mission objectives are briefly reviewed to establish the level of technology required. In particular, power and attitude control sub-systems are evaluated to characterize their functional interaction. Proposed wheel arrays are presented and compared to alternative electrochemical systems. These comparisons indicate that in terms of mass, volume, and reliability, flywheels for satellite applications are preferable. The concise design synthesis of the integrated energy storage and attitude control system concept is presented as well as the technical indexes. Author (ESA)

**N80-11623/** Oklahoma Univ., Norman. School of Aerospace, Mechanical and Nuclear Engineering

**WHIRLING RESPONSE AND STABILITY OF FLEXIBLY MOUNTED, RING-TYPE FLYWHEEL SYSTEMS**

T. L. C. Chen and C. W. Bert Nov. 1978 122 p refs

(Contract EY-76-C-04-0789)

(SAND-78-7073; OU-AMNE-78-6)

Avail: NTIS

HC A06/MF A01

Rim type composite material flywheels are examined. Free whirling, stability, and forced whirling are examined for these fly-wheel systems. In the free whirling analysis, predicted critical speeds are encountered in the design operating speed range. Practical ways to increase such critical speeds are suggested. Effects of material internal damping on the stability of the system are discussed. DOE

✓ 79A16729 ISSUE 4 PAGE 655 CATEGORY 44 78/00/00  
5 PAGES UNCLASSIFIED DOCUMENT

UTTL: Flywheel energy storage system for JT-60 toroidal field coil

AUTH: A/KISHIMOTO, H.; B/SHIMADA, R.; C/TAMURA, S.;  
D/ITO, S.; E/SAWADA, Y.; F/TAKANO, H.; G/FURUSAWA,  
T.; H/KIMURA, K. PAA: C/(Japan Atomic Energy  
Research Institute, Tokai, Japan); H/(Tokyo Shibaura  
Electric Co., Ltd., Yokohama, Japan)  
In: Energy '78; Annual Conference, Tulsa, Okla., April  
16-18, 1978. Record of Conference Papers. (A79-16726  
04-44; New York, Institute of Electrical and  
Electronics Engineers, Inc., 1978, p. 11-15.

MAJS: /\*ENERGY STORAGE/\*FLYWHEELS/\*HIGH FIELD MAGNETS/\*  
MAGNET COILS/\*PLASMA CONTROL/\*TOROIDAL PLASMAS

MINS: / CONTROLLED FUSION/ ELECTRIC POWER SUPPLIES/ ENERGY  
TECHNOLOGY/ OPTIMIZATION/ REACTOR DESIGN/ SYSTEMS  
ENGINEERING

ABA: B.J.

ABS: For plasma confinement in large fusion devices, a  
magnetic field of several teslas is necessary. The  
large pulsed power supply requirement can be met with  
a flywheel energy storage system. This paper presents  
a detailed investigation of the flywheel energy  
storage system for the JT-60 toroidal field coil based  
on parameter studies with regard to the following: (1)  
optimum hybrid system of M-G (motor-generator)  
flywheel set and electric power from the commercial  
power line; (2) preliminary design comparison between  
the vertical shaft waterwheel type low speed M-G set  
and horizontal high speed M-G set; and (3) optimum  
choice of design parameters in the case of a vertical  
shaft waterwheel type low speed M-G set.

✓ 79N79285# CATEGORY 44 RPT#: BMFT-FB-T-78-11  
78/11/00 153 PAGES In GERMAN UNCLASSIFIED  
DOCUMENT

UTTL: Stationary flywheel energy storage system SSB

AUTH: A/ZWERENZ, W.; B/SCHAUBERGER, H.  
CORP: Maschinenfabrik Augsburg-Nuernberg A.G., Munich (West  
Germany). AVAIL NTIS

MAJS: /\*ELECTROMECHANICAL DEVICES/\*ENERGY CONVERSION/\*ENERGY  
CONVERSION EFFICIENCY/\*FLYWHEELS/\*REGENERATION  
(ENGINEERING)

MINS: / COST ANALYSIS/ DIRECT POWER GENERATORS/ ELECTRIC  
POWER PLANTS/ ENERGY CONSUMPTION/ PASSAGEWAYS/ RAIL  
TRANSPORTATION

✓ 79N11536# ISSUE 2 PAGE 207 CATEGORY 44 RPT#:  
UCRL-81159 CONF-780587-1 CNT#: W-7405-ENG-48  
78/05/00 25 PAGES UNCLASSIFIED DOCUMENT

UTTL: Evaluated physical properties data for materials used  
in energy storage systems

AUTH: A/HAMPEL, V. E.; B/GEVANTMAN, L. H. PAA: B/(NBS,  
Washington, D.C.)

CORP: California Univ., Livermore. Lawrence Livermore Lab.  
AVAIL NTIS SAP: HC A02/MF A01  
Presented at the 6th Intern. CODATA Conf., Palermo,  
Italy, 22-25 May 1978

MAJS: /\*ENERGY STORAGE/\*MATERIALS TESTS/\*PHYSICAL PROPERTIES

MINS: / COST EFFECTIVENESS/ DECISION MAKING/ ELECTRIC  
BATTERIES/ EVALUATION/ FLYWHEELS/ HEAT STORAGE

ABA: DOE

ABS: The Lawrence Livermore Laboratory under contract to  
the Division of Energy Storage Systems of the U.S.  
Department of Energy (DOE/STOR). Identifies materials  
and properties required for batteries, flywheels, and  
for thermal or chemical systems. The users of these  
data set the priorities for evaluation. Requests are  
forwarded to the Office of Standard Reference Data of  
the National Bureau of Standards (NBS/OSRD) which  
selects and engages other sources of expertise. In  
addition, OSRD manages and monitors the output of data  
evaluations prior to their being published as part of  
the NSRD/NBS series, and prior to their being stored  
on a PDP-11/70 mini-computer for subsequent access  
through the Integrated Information System at LLL.  
Administrators of DOE/STOR, researchers, engineers and  
DOE contractors can thus assess the physical  
properties in a selective, concise, and up-to-date  
manner on demand over the ARPAnet and by telephone  
dial-up from remote terminals nationwide.

✓ BON15612# ISSUE 6 PAGE 764 CATEGORY 44 RPT#:  
UCRL-81772 CONF-781046-4 CNT#: W-7405-ENG-48  
78/10/24 9 PAGES UNCLASSIFIED DOCUMENT

UTTL: Laminated disk flywheel program

AUTH: A/STONE, R. G.

CORP: California Univ., Livermore. Lawrence Livermore Lab.  
AVAIL NTIS SAP: HC A02/MF A01  
Presented at the Inform. Exchange Conf., Lunay, Va.,  
24 Oct. 1978

MAJS: /\*ENERGY STORAGE/\*FLYWHEELS/\*PROJECT PLANNING/\*  
ROTATING DISKS

MINS: / FIBER COMPOSITES/ LAMINATES/ PROJECT MANAGEMENT/  
STRUCTURAL DESIGN

ABA: A.W.H.

ABS: A program to develop the technology for high energy  
density, fiber composite flywheels based on the  
laminated disk concept is described. Progress toward  
optimizing the flywheel energy system with respect to  
low volume, low weight, manufacturability, and economy  
is reported. Program planning areas including the  
manufacturing of test model flywheels and developing a  
hub attachment are discussed.

79A20843 ISSUE 7 PAGE 1229 CATEGORY 44  
78/00/00 16 PAGES UNCLASSIFIED DOCUMENT

UTTL: A status of the 'Alpha-ply' composite flywheel concept development

AUTH: A/LUSTENADER, E. L.; B/ZORZI, E. S. PAA: B/(General Electric Co., Fairfield, Conn.)

In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978. p. 712-727.

MAJS: /\*COMPOSITE STRUCTURES/\*FAILURE ANALYSIS/\*FLYWHEELS/\*GLASS FIBER REINFORCED PLASTICS/\*KEVLAR (TRADEMARK)/\*STRUCTURAL DESIGN

MINS: / ENERGY STORAGE/ FIBER ORIENTATION/ FINITE ELEMENT METHOD/ GRAPHITE/ LOW DENSITY MATERIALS/ MECHANICAL PROPERTIES/ PERFORMANCE PREDICTION

ABA: M.L.

ABS: The development of the pseudo-isotropic flywheel

concept 'Alpha-ply' is discussed. Analytic and experimental results are presented, and the finite-element evaluation of the concept is described. The construction of the low-cost reliable and moderate-energy-density flywheel (potential energy density as high as 30 Wh/lb) consists of a layup of composite glass material into a uniform thickness disk. Reasons for the failure of the first 30-in. od E-glass/Kevlar-wrapped alpha 2 wheel are suggested.

79A34139 ISSUE 13 PAGE 2425 CATEGORY 44  
78/00/00 21 PAGES UNCLASSIFIED DOCUMENT

UTTL: Energy storage by flywheels - A new flywheel concept

AUTH: A/VANCE, J. M.; B/HOLTZCLAW, E. H.; C/SCHNEIDER, R. T. PAA: C/(Florida, University, Gainesville, Fla.)

In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9. (A79-34131 13-44)

Washington, D.C., Hemisphere Publishing Corp., 1978. p. 4057-4077.

ABA: (Author)

ABS: A flexible, toroidal flywheel design is described. This flywheel is constructed from synthetic fibers which are not laminated. The flexible configuration is expected to minimize synchronous vibration, and experimental results verify that the flywheel tends to be self balancing. The main advantages are safety and economy. The flywheel will not explode or disintegrate without prior warning. It is also simple and inexpensive to manufacture. These factors seem to point toward flywheel use as a small scale device. As such, it could be used as a storage unit for individual households to yield energy when brown-out conditions occur. It might also be used as a source of emergency power. Due to inherent mechanical simplicity, the flywheel is a reliable storage system.

79A20853 ISSUE 7 PAGE 1230 CATEGORY 44 CNT#:  
W-7405-ENG-48 78/00/00 21 PAGES UNCLASSIFIED DOCUMENT

UTTL: Current status of composite flywheel development

AUTH: A/TOLAND, R. H. PAA: A/(California, University, Livermore, Calif.)

In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978. p. 856-876.

MAJS: /\*COMPOSITE STRUCTURES/\*ENERGY STORAGE/\*FIBER COMPOSITES/\*FLYWHEELS/\*TECHNOLOGY ASSESSMENT/\*TRANSPORTATION ENERGY

MINS: / GOVERNMENT/INDUSTRY RELATIONS/ RESEARCH AND DEVELOPMENT/ STRUCTURAL DESIGN

ABA: (Author)

ABS: The paper surveys the recent developments in the applications of fiber composite materials to flywheel energy storage systems. The impact of these materials on flywheel energy storage is discussed in relation to transportation systems, specifically the performance requirements and the effect of system constraints on the ultimate effectiveness of the composite rotors. General flywheel design concepts are discussed in light of several performance criteria and the inherent design and material limitations, including those affecting reliability and life. Specific composite rotors that have been built and tested are discussed in terms of their demonstrated performance and are assessed for their potential. Also, recent government-sponsored research and development programs are briefly reviewed, and recommendations are made for future work.

N80-15612# California Univ. Livermore. Lawrence Livermore Lab.

#### LAMINATED DISK FLYWHEEL PROGRAM

Richard G. Stone 24 Oct 1978 9 p refs Presented at the Inform. Exchange Conf., Luray, Va. 24 Oct 1978

(Contract W-7405-eng-48)

(UCRL-81772; CONF-781046-4)

Avail: NTIS

HC A02/MF A01

A program to develop the technology for high energy density, fiber composite flywheels based on the laminated disk concept is described. Progress toward optimizing the flywheel energy system with respect to low volume, low weight, manufacturability, and economy is reported. Program planning areas including the manufacturing of test model flywheels and developing a hub attachment are discussed.

A.W.H.



✓ 79N30835# ISSUE 21 PAGE 2854 CATEGORY 44 RPT#:  
 REPT-30/1020-VOL-2 ESA-CR(P)-1168-VOL-2 CNT#:  
 ESA-3261/77/NL-AK 78/10/00 2 VOLS 262 PAGES  
 UNCLASSIFIED DOCUMENT DCAF E003091

UTTL: Study of system implications of high speed flywheels as energy storage devices on satellites, volume 2  
 AUTH: A/NGUYEN, H. N.; B/MARIAU, F.  
 CORP: Engins Matra, Velizy (France). CSS: (Automatisme Dept.) AVAIL:NTIS SAP: HC A12/MF A01  
 MAJS: /\*ENERGY STORAGE/\*FEASIBILITY ANALYSIS/\*FLYWHEELS/\* SATELLITE ATTITUDE CONTROL  
 MINS: / ANTI-FRICTION BEARINGS/ COMMUNICATION SATELLITES/ COST ESTIMATES/ ELECTROCHEMICAL CELLS/ MAGNETIC SUSPENSION/ SYSTEMS COMPATIBILITY  
 ABA: Author (ESA)  
 ABS: The feasibility of integrated energy storage and attitude control systems using high speed flywheels is demonstrated. The impact of magnetic bearing technologies on these flywheel applications is assessed. The flywheel designs for different mission objectives are briefly reviewed at the level of technology required. In particular, power and attitude control sub-systems are evaluated to characterize their functional interaction. Proposed wheel arrays are presented and compared to alternative electrochemical systems. These comparisons indicate that in terms of mass, volume, and reliability flywheels for satellite applications are preferable. This report exists as two volumes. Volume 1 contains the concise design synthesis of the Integrated Energy Storage and Attitude Control System concept. Volume 2 contains the technical appendixes.

✓ 78A29600# ISSUE 11 PAGE 2002 CATEGORY 44  
 78/02/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: For the latest in energy storage, try the flywheel  
 AUTH: A/CHANG, G. C.; B/HIRSCHFELD, F. PAA: A/(ERDA, Div. of Energy Storage Systems, Washington, D.C.)  
 Mechanical Engineering, vol. 100, Feb. 1978, p. 38-45.  
 MAJS: /\*BRAKING/\*COMPOSITE MATERIALS/\*ENERGY STORAGE/\* FLYWHEELS  
 MINS: / AUTOMOBILES/ ENERGY CONSERVATION/ ENGINE DESIGN/ FLUX DENSITY/ LIFE (DURABILITY)/ ROUND TRIP TRAJECTORIES/ SPIN REDUCTION  
 ABA: D.M.W.  
 ABS: Composite materials have made possible the construction of flywheels of light weight and high durability. Applications of the flywheel technique of energy storage are discussed with reference to automotive use. Energy otherwise dissipated during braking is stored by a flywheel to be used again during acceleration (regenerative braking). Various flywheel configurations are evaluated in terms of energy density, round trip efficiency, lifetime in years, and fixed spinning losses (stored energy).

✓ 79N24488# ISSUE 15 PAGE 2006 CATEGORY 44 RPT#:  
 FE-8890 CNT#: ET-77-C-01-8890 78/08/00 335 PAGES  
 UNCLASSIFIED DOCUMENT

UTTL: Evaluation of a flywheel-powered shuttle car TLSP:  
 Final Technical Report as of 25 Aug. 1978  
 AUTH: A/BOUCHERON, P. H.; B/CAIN, D. E.; C/RUBENSTEIN, A. S.  
 CORP: General Electric Co., Schenectady, N. Y. AVAIL:NTIS  
 SAP: HC A15/MF A01  
 MAJS: /\*ENERGY STORAGE/\*FLYWHEELS/\*MINES (EXCAVATIONS)/\* SURFACE VEHICLES  
 MINS: / ENERGY TRANSFER/ FEASIBILITY ANALYSIS/ MECHANICAL ENGINEERING/ OPERATIONS RESEARCH  
 ABA: DOE  
 ABS: The practical application of flywheel-stored energy devices to shuttle cars in underground coal mining was evaluated along with practical methods of charging, recovery, and transmitting flywheel energy so as to provide power for the necessary functions of a shuttle car. The general conclusions indicate that the mine mission requirements can be fulfilled with a flywheel energy storage system which can be designed within the present state-of-the-art, that a flywheel system can yield sufficient economic benefits to warrant a mine demonstration, and that there is promise of safety improvements due to elimination of the trailing cable presently used. In addition, it is indicated that specific operation problems associated with a flywheel-powered vehicle, like emergency movement of the vehicle and transmission of energy from the wayside to the vehicle, can be satisfactorily solved.

79N-30835# Engins Matra, Velizy (France). Automatisme Dept.

**STUDY OF SYSTEM IMPLICATIONS OF HIGH SPEED FLYWHEELS AS ENERGY STORAGE DEVICES ON SATELLITES, VOLUME 2**

H. Nghia Nguyen and Francois Mariau Oct. 1978 262 p refs 2 Vol.

(Contract ESA-3261/77/NL-AK)

(Rept-30/1020-Vol-2: ESA-CR(P)-1168-Vol-2) Avail: NTIS HC A12/MF A01

The feasibility of integrated energy storage and attitude control systems using high speed flywheels is demonstrated. The impact of magnetic bearing technologies on these flywheel applications is assessed. The flywheel designs for different mission objectives are briefly reviewed at the level of technology required. In particular, power and attitude control sub-systems are evaluated to characterize their functional interaction. Proposed wheel arrays are presented and compared to alternative electrochemical systems. These comparisons indicate that in terms of mass, volume, and reliability flywheels for satellite applications are preferable. This report exists as two volumes. Volume 1 contains the concise design synthesis of the Integrated Energy Storage and Attitude Control System concept. Volume 2 contains the technical appendixes.  
 Author (ESA)



79N11550# ISSUE 2 PAGE 209 CATEGORY 44 RPT#:  
NTIS/PS-78/0997/3 NTIS/PS-77/0882 NTIS/PS-76/0767  
NTIS/PS-75/743 NTIS/PS-75/070 78/09/00 263 PAGES  
UNCLASSIFIED DOCUMENT  
Supersedes NTIS/PS-77/0882; NTIS/PS-76/0767;  
NTIS/PS-75/743; NTIS/PS-75/070

UTTL: Design and applications of flywheels. Citations from  
the NTIS data base TLSP: Progress Report, 1964 -  
Aug. 1978

AUTH: A/HABERCOM, G. E., JR.

CORP: National Technical Information Service, Springfield,  
Va. AVAIL: NTIS SAP: HC \$28.00/MF \$28.00

MAJS: /\*BIBLIOGRAPHIES/\*FLYWHEELS/\*REACTION WHEELS

MINS: / ENERGY STORAGE/ RAIL TRANSPORTATION/ SATELLITE

ATTITUDE CONTROL/ WINDPOWER UTILIZATION

ABA: GRA

ABS: The design and varied applications of flywheels and  
reaction wheels are investigated. Such diversified  
applications as satellite stabilization, surface  
vehicle propulsion, energy transfer devices, and  
inertial or friction welding are reviewed. This  
updated bibliography contains 258 abstracts, 74 of  
which are new entries to the previous edition.

78N33560# ISSUE 24 PAGE 3237 CATEGORY 44 RPT#:  
ALO-41/1 CNT#: EY-76-C-04-0789 78/04/00 151 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Study of heat engine/flywheel: Hybrid propulsion  
configuration with electrical transmission system,  
phase 1 TLSP: Final Report

CORP: AiResearch Mfg. Co., Torrance, Calif. AVAIL: NTIS  
SAP: HC A08/MF A01

MAJS: /\*AUTOMOBILE ENGINES/\*ENERGY POLICY/\*FLYWHEEL/\*FUEL  
CONSUMPTION

MINS: / ENERGY CONSERVATION/ ENERGY CONVERSION EFFICIENCY/  
ENERGY TECHNOLOGY

ABA: ERA

ABS: Mechanical and electronic options for the system were  
evaluated in a five passenger family sedan and were  
ranked according to cost, weight, and fuel economy.  
The primary use of this transmission system is to  
augment the heat engine with energy from the flywheel  
in such a manner as to level engine loads and improve  
the overall vehicle efficiency. The benefits of using  
this system are as follows: (1) provides fuel economy,  
which is unobtainable with conventional propulsion  
arrangements; (2) acceleration and passing performance  
same as provided by large V-8 engine; (3) meets 1985  
Federal emission standards; (4) reduces direct  
operating cost for the consumer; and (5) reduces heat  
engine size. The hybrid's fuel consumption is 35.5  
mpg, compared to 15 mpg projected for a conventional  
vehicle. This represents a 263% improvement in fuel  
economy. The hybrid also provides a 40% savings in  
direct operating cost.

N80-12597# Oklahoma Univ., Norman. School of Aerospace,  
Mechanical and Nuclear Engineering

RESEARCH ON THE DYNAMICS OF BAND-SUPPORTED  
FLYWHEEL SYSTEMS Final Report

C. W. Bert, C. A. Kocay, T. L. Chen, and J. P. Busby Nov.  
1978 61 p refs

(Contract EY-76-C-04-0789)

(SAND-78-7074) Avail: NTIS HC A04/MF A01

Analytical research is reported relating to various aspects of  
the dynamics of band-supported, composite-material-rim flywheel  
energy-storage systems for application in hybrid automotive  
vehicles. A parametric study is carried out for free whirling of a  
flywheel system with a flywheel shaft supported by ball  
bearings, typical of a class of configurations contemplated in  
vehicular application as distinguished from R and D spin tests.  
It is shown that for a wide range of combinations of hub location  
and bearing and shaft stiffnesses, it is possible to avoid having  
any potentially dangerous forward-precession critical speeds  
throughout the desired operating range of 8,000 to 32,000 rpm.  
Nonlinear analyses are presented to describe the behavior of  
the bands in both the translational and tilting modes. The primarily  
softening behavior is geometrically induced and can lead to  
buckling at relatively small amplitudes. The band behaviors are  
approximated by polynomial expansions and applied to analyses  
of the steady-state forced whirling response. An analysis is  
presented for the behavior of a ring-type containment system  
after failure of the bands. This analysis combines Hertzian impact  
theory with an analysis of ring response to a concentrated load  
of half-sine waveform. It is shown that a 1-inch thick aramid-epoxy  
ring should provide satisfactory containment. Small model studies  
were initiated to study some of the nonlinear and containment  
phenomena. DOE

A79-20841 Design and material considerations in the  
fabrication of an optimized fiber composite flywheel. W. E. Dick  
(Brunswick Corp., Lincoln, Neb.) and R. F. Foral (Nebraska,  
University, Lincoln, Neb.). In: Selective application of materials for  
products and energy; Proceedings of the Twenty-third National  
Symposium and Exhibition, Anaheim, Calif., May 24, 1978.  
(A79 20801 07 23) Azusa, Calif., Society for the Advancement of  
Material and Process Engineering, 1978, p. 675-702. 6 refs.

A major design problem associated with fiber composite  
flywheels is the relatively poor transverse strength of these materials.  
Work reported earlier resulted in improved transverse strength,  
especially for Kevlar composites. This paper reports the results of  
applying these improved properties to an optimized hoop-wound  
design and presents a parametric study to show the sensitivity of  
flywheel performance to composite properties. Single material and  
hybrid construction are compared. A discussion of fabrication  
methods and their effect on flywheel performance and producibility  
is included. (Author)

# A COMPOSITE - RIM FLYWHEEL DESIGN.

E. D. Reedy, Jr.

SAMPE Quarterly, Vol. 9, No. 3, April 1978,  
p. 1-6.

This paper describes the design of a flywheel which incorporates a circumferentially wound rim. The design required the selection of materials and configuration for rim and hub, and a means of attaching the rim to the hub. The method used to fabricate prototype flywheels of this design is discussed.

A79-20840 A composite-rim flywheel design. E. D. Reedy, Jr. (Sandia Laboratories, Albuquerque, N. Mex.). In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 663-674. 15 refs. Research supported by the U.S. Department of Energy.

The design of a flywheel incorporating a circumferentially wound rim is described. The flywheel is required to satisfy weight and size limitations which seem appropriate for utilization in a hybrid vehicle. Attention is given to the selection of materials and configuration for rim and hub, and to a method of attaching the rim to the hub. The rim material and design are chosen to optimize the rotor's energy storage capacity. Also, a method of fabricating prototype flywheels is described. Analysis of constant-thickness rims identified a graphite/epoxy rim with an inner-to-outer radius ratio of 0.775 as having the highest energy storage capacity of all design and material choices considered. This rim is used as the basis of a thick-rim flywheel design. The wagon wheel design incorporates a tubular aluminum hub and overwrapped Kevlar 49/epoxy bands. At 32,000 rpm, this flywheel can deliver 0.5-kWh energy with a three to one speed reduction. S.D.

N80-11622# Oklahoma Univ., Norman. School of Aerospace, Mechanical and Nuclear Engineering.

## LATERAL AND TILT WHIRL MODES OF FLEXIBLY MOUNTED FLYWHEEL SYSTEMS

C. W. Bert and T. L. C. Chen Dec. 1978 36 p refs Presented at the 49th Shock and Vibration Symp., Washington, D. C., 17-19 Oct. 1978 Prepared for Sandia Labs. (Contract EY-76-C-04-0789) (SAND-78-7070; OU-AMNE-78-5; Conf-7810154-1) Avail: NTIS HC A03/MF A01

High performance, composite material flywheel systems were driven by an air turbine at the Sandia Livermore spin test facility. An analysis of the systems considering six degrees of freedom was applied to two versions of a specific design. DOE

A79-20843

## A status of the 'Alpha-ply' composite flywheel

concept development. E. L. Lustenader and E. S. Zorzi (General Electric Co., Fairfield, Conn.). In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 712-727.

The development of the pseudo-isotropic flywheel concept 'Alpha-ply' is discussed. Analytic and experimental results are presented, and the finite-element evaluation of the concept is described. The construction of the low-cost reliable and moderate-energy-density flywheel (potential energy density as high as 30 Wh/lb) consists of a layup of composite glass material into a uniform thickness disk. Reasons for the failure of the first 30-in. od E-glass/Kevlar-wrapped alpha 2 wheel are suggested. M.L.

N78-29605# California Univ., Livermore. Lawrence Livermore Lab.

## CURRENT STATUS OF COMPOSITE FLYWHEEL DEVELOPMENT

Richard H. Toland 17 Jan. 1978 23 p refs Presented at the 23d Natl. SAMPE Symp., Anaheim, Calif., 1-4 May 1978 (Contract W-7405-eng-48)

(UCRL-80604; Conf-780502-4)

Avail: NTIS

HC A02/MF A01

Recent developments in the applications of fiber composite materials to flywheel energy storage systems are reviewed. The impact of these materials on flywheel energy storage is discussed, in relation to transportation systems, specifically the performance requirements and the effect of system constraints on the ultimate effectiveness of the composite rotors. General flywheel design concepts are discussed, in light of several performance criteria and the inherent design and material limitations, including those affecting reliability and life. Specific composite rotors that were built and tested are discussed in terms of their demonstrated performance and are assessed for their potential. Recent government-sponsored research and development programs also are briefly reviewed and recommendations are made for future work. ERA

A78-29600 # For the latest in energy storage, try the flywheel. G. C. Chang (ERDA, Div. of Energy Storage Systems, Washington, D.C.) and F. Hirschfeld. *Mechanical Engineering*, vol. 100, Feb. 1978, p. 38-45. 5 refs.

Composite materials have made possible the construction of flywheels of light weight and high durability. Applications of the flywheel technique of energy storage are discussed with reference to automotive use. Energy otherwise dissipated during braking is stored by a flywheel to be used again during acceleration (regenerative braking). Various flywheel configurations are evaluated in terms of energy density, round trip efficiency, lifetime in years, and fixed spinning losses (stored energy). D.M.W.

A79 20511 On vibration of a thick flexible ring rotating at high speed. C. W. Bert and T. L. C. Chen (Oklahoma, University, Norman, Okla.). (U.S. National Congress of Applied Mechanics, 8th, University of California, Los Angeles, Calif., June 26-30, 1978.) *Journal of Sound and Vibration*, vol. 61, Dec. 22, 1978, p. 517-530. 23 refs. Research supported by the U.S. Department of Energy.

In connection with high-performance flywheel energy storage systems containing a thick ring as the primary storage element, there is considerable current interest in the vibrational modes of such an element. In the present analysis both in-plane bending and coupled twisting/out-of-plane bending modes are considered. It is believed to be the first to include either transverse shear deformation or support restraint in the vibrational analysis of rotating rings. Numerical results are presented for a specific flywheel system currently under development. (Author)

N78-31529 Ohio State Univ., Columbus.  
**A VARIABLE INERTIA FLYWHEEL AS AN ENERGY STORAGE SYSTEM** Ph.D. Thesis  
David Gordon Ullman 1978 216 p  
Avail. Univ. Microfilms Order No. 7812395

A variable inertia flywheel (VIF) system was designed and fabricated to verify theoretical predictions and to evaluate the basic operating characteristics of the concept. A fully controllable VIF, full control over the moment of inertia irrespective of the VIF state, is not practical as the efficiency obtained can be no better than a fixed inertia flywheel with an infinitely variable ratio transmission. However, a VIF with a fixed power recirculation results in a flywheel with a unique torque/angular rate characteristic. A VIF can theoretically be formed such that the torque is related to any function of angular rate. Dissert. Abstr.

N79-11551# National Technical Information Service, Springfield, Va.

**DESIGN AND APPLICATIONS OF FLYWHEELS. CITATIONS FROM THE ENGINEERING INDEX DATA BASE** Progress Report, 1970 - Sep. 1978

Guy E. Habercom, Jr. Sep. 1978 228 p Supersedes NTIS/PS 77/0883, NTIS/PS 76/0768  
(NTIS/PS 78/0998/1; NTIS/PS 77/0883, NTIS/PS 76/0768)  
Avail. NTIS HC \$28.00/MF \$28.00 CSCI 131

A worldwide literature survey was conducted to obtain information on the design and varied applications of flywheels and reaction wheels. Such diversified applications as satellite stabilization, surface vehicle propulsion, energy transfer devices, and inertia or friction welding are reviewed. This updated bibliography contains 222 abstracts, 42 of which are new entries to the previous edition. GRA

TA  
418.9  
.C6  
A3  
1978

National SME Symposium and Exhibition, 23rd, Anaheim, Calif., 1978.

Selective application of materials for products and energy / Society for the Advancement of Material and Process Engineering. — Azusa, Calif. : Society for the Advancement of Material and Process Engineering, c1978.

A COMPOSITE-RIM FLYWHEEL DESIGN 663

E.D. Reedy, Jr.

DESIGN AND MATERIAL CONSIDERATIONS IN THE FABRICATION OF AN OPTIMIZED FIBER COMPOSITE FLYWHEEL 675

William E. Dick and Ralph F. Foral

COMPOSITE MATERIAL FLYWHEEL FOR THE ELECTRIC-POWERED PASSENGER VEHICLE 703

D. A. Towgood and D. L. Satchwell

A STATUS OF THE "ALPHA-PLY" COMPOSITE FLYWHEEL CONCEPT DEVELOPMENT 712

E. L. Lustenader and E. S. Zorzi

OPTIMAL DESIGN OF FIBER COMPOSITE FLYWHEELS REINFORCED BESIDES CIRCUMFERENTIALLY 728

O-11 Byon and Kazuji Uemura

FLYWHEEL ENERGY ACCUMULATORS FOR ROAD VEHICLES 740

G. Hanselmann and E. Hau

STRENGTH OF THE CIRCUMFERENTIALLY FIBER-REINFORCED COMPOSITE ROTOR 748

*Journal of Dynamic Systems, Measurement and Control*, v.100, no.4

Dec.  
1978

TRANSPORTATION. (Special issue).

284 Optimal Control of On-Board and Station Flywheel Storage for Rail Transit Systems  
L. M. Sweet and M. J. Keane



TA National SME Symposium and Exhibition, 23rd,  
 418.9 Anaheim, Calif., 1978.  
 .C6 Selective application of materials for  
 A3 products and energy ... c1978.  
 1978 (Card 2)

Includes bibliographical references and  
 index.

1. Materials—Congresses. I. Society  
 for the Advancement of Material and Process  
 CURRENT STATUS OF COMPOSITE FLYWHEEL DEVELOPMENT 856

Richard H. Toland

TA National SME Symposium and Exhibition, 23rd,  
 418.9 Anaheim, Calif., 1978.  
 .C6 Selective application of materials for  
 A3 products and energy / Society for the  
 1978 Advancement of Material and Process Engi-  
 neering. — Azusa, Calif. : Society for the  
 Advancement of Material and Process Engi-  
 neering, c1978.  
 xix, 1240 p. : ill. — (Science of advanced

COMPOSITE MATERIAL FLYWHEELS FOR ENERGY STORAGE ON ELECTRI- 846  
 CITY SUPPLY SYSTEMS

Peter J. Worthington

TJ Energy Technology Conference, 5th, Washington,  
 153 D.C., 1978.  
 .E4787 Energy technology V : challenges to  
 1978 technology : proceedings of the fifth  
 Energy Technology Conference, February 27-  
 March 1, 1978, Washington, D.C. / edited by  
 Richard F. Hill. — Washington : Government  
 Institutes, 1978.  
 xiii, 1063 p. : ill.  
 1. Power (Mechanics)—Congresses.

FLYWHEELS FOR VEHICLES p.167  
 John L. Mason, Vice President — Engineering, The Garrett Corporation

# FIBER COMPOSITE MATERIALS AND THEIR APPLICATION TO ENERGY-STORAGE FLYWHEELS

T.T. Chiao  
 Energy Technology,  
 pp.1-12

June 1978,

Fiber composites—fiber-reinforced poly-  
 mers—have been used with increasing popularity over  
 the past 50 years. These strong, lightweight materials  
 have found numerous applications in reinforced  
 plastics and reinforcing fibers. At LLL, the Fiber  
 Composites and Mechanics Group is responsible for  
 investigating these promising materials and for sup-  
 porting the Laboratory with comprehensive fiber  
 composite technology. Our effort includes not only  
 the basic long-term performance evaluation and  
 development of filament-winding fabrication tech-  
 niques, but also materials characterizations, fracture  
 mechanics theory, lifetime and reliability predictions,  
 and fatigue and creep behavior. Although we are  
 presently involved in projects ranging from weaponry  
 to energy storage, in this article we will discuss only  
 one of our major programs: fiber composite energy-  
 storage flywheels.

(SAND—0985C) Design of spoked-rim composite fly-  
 wheels. Reedy, E.D. Jr.; Gerstle, F.P. Jr. (Sandia Labs., Albuquer-  
 que, N.Mex. (USA)). 1977. Contract EY-76-C-04-0789. 12p. (CONF-  
 771053—1). Dep. NTIS, PC A02/MF A01.

From Flywheel technology symposium; San Francisco, Cali-  
 fornia, USA (5 Oct 1977).

Design and material choices which optimize the energy stor-  
 age capacity of a free-spinning, circumferentially wound rim fly-  
 wheel are identified. The rim designs considered were (1) a rim  
 fabricated from a single material, (2) a rim with lead ballast uniform-  
 ly distributed along its interior edge, and (3) a rim composed of two  
 concentrically wound materials. The composite rims examined were  
 reinforced with graphite, Kevlar 49, Kevlar 29, G-glass, and E-glass.  
 The rims were required to satisfy weight, size and angular speed  
 limitations which appear appropriate for a hybrid heat engine/  
 flywheel propulsion system. A graphite/epoxy rim with an inner-to-  
 outer-radius ratio of 0.775 was found to have the largest energy  
 storage capacity.



#### Prestressed Thick Flywheel Rims.

C. E. Knight, Jr., and R. E. Pollard.

Oak Ridge Y-12 Plant, Tenn. 1977, 10p CONF-771053-4

Y/DA-7291 Price code: PC A02/MF A01

A homogeneous fiber composite flywheel rim has a radial tensile stress distribution when spinning about its axis of cylindrical symmetry. A circ-wound rim is ideally suited to support the very high hoop stresses, but it can only support very low radial tensile stresses. This limits the allowable rim inside-to-outside radius ratio so that the energy stored per unit volume is low. It would be desirable to have relatively thicker rims with no radial tensile stresses at the ultimate design speed for hoop stress failure. The methods for calculating the prestress produced by a given schedule of winding tensions are given. The significant parameters to be controlled in the fabrication process are presented. Some tension schedules for balancing the radial rotational stress in rims of a specific size and material are also presented. Experimental development of prestress conditions in small scale test ring demonstrates the capability to achieve prestress levels that can effectively eliminate radial tensile stress in the composite thick rim. Successful experimental development led to the fabrication of a full scale prestressed flywheel rim and utilization of that rim in the Oak Ridge Y-12 Plant FY 1977 flywheel test package. (ERA citation 03.010493)

77A22143 ISSUE 8 PAGE 1253 CATEGORY 44

77/01/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Fiber glass super flywheels

AUTH: A/ROLSTON, J. A. PAA: A/Owens-Corning Fiberglas Technical Center, Granville, Ohio

SAMPE Quarterly, vol. 8, Jan. 1977, p. 7-12.

MAJS: /ENERGY STORAGE/ FLYWHEELS/ GLASS FIBER REINFORCED PLASTICS/ MECHANICAL PROPERTIES

MINS: / COST EFFECTIVENESS/ DESIGN ANALYSIS/ ELASTOMERS/ KINETIC ENERGY/ STRESS ANALYSIS/ STRESS CONCENTRATION/ TENSILE STRENGTH

ABA: (Author)

ABS: Light weight flywheels of fiber glass reinforced epoxy can store more energy at lower cost than the equivalent weight of alloy steel. In competition with batteries, the composite flywheel stores more energy per pound with an unlimited number of charge/discharge cycles. The operating stresses for flywheels are near the ultimate long term strength of the composite. Several composite flywheel design concepts have been proposed; the principal ones are the 'multi-ring' and the 'brush'.

#### Analysis of the Deltawrap Flywheel Design.

C. E. Knight, Jr.

Oak Ridge Y-12 Plant, Tenn. 1977, 9p CONF-771053-6

Y/DA-7292 Price code: PC A02/MF A01

The higher shape efficiency of the isotropic constant stress disc profile is brought about by the transfer of body force loading in the outermost portions of the disc back to the disc hub region. This is difficult to accomplish with a fiber composite disc because of its low transverse strength. However, the same end might be accomplished in a rim type flywheel design through use of a full overwrap around the rim, tying back to the hub. This is an extension of the "Bandwrap" design but involves considerably more analysis complexities. A model and computer program developed at the Oak Ridge Y-12 Plant calculates the thickness and elastic properties versus position on the overwrap. The thickness is calculated based on coverage per band, number of bands, and band thickness at a given radial coordinate. The elastic properties are derived assuming the overwrap material to be modeled by the properties of an angle ply laminate. The thickness and properties provide input to a finite element model. A linear, elastic finite element analysis provides an estimate of the energy storage potential for this design. The model was two-dimensionally axisymmetric and was analyzed using the ADINA finite element program. (ERA citation 03.012500)

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Intersociety Energy Conversion Engineering Conference, 12th, Washington, 1977.

Proceedings of the 12th Intersociety Energy Conversion Engineering Conference, Washington, D. C., August 28 through September 2, 1977. — La Grange, Ill. : American Nuclear Society, c1977.

2 v. : ill. ; 29 cm.

779085 — Energy Storage—An Interference Assembled Multiring Superflywheel, J. A. Kirk, R. A. Huntington, University of Maryland, College Park, Md. .... 5171

**A79-34139** Energy storage by flywheels - A new flywheel concept. J. M. Vance, E. H. Holtzclaw, and R. T. Schneider (Florida, University, Gainesville, Fla.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9. (A79-34131 13-44) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4057-4077. 8 refs.

A flexible, toroidal flywheel design is described. This flywheel is constructed from synthetic fibers which are not laminated. The flexible configuration is expected to minimize synchronous vibration, and experimental results verify that the flywheel tends to be self balancing. The main advantages are safety and economy. The flywheel will not explode or disintegrate without prior warning. It is also simple and inexpensive to manufacture. These factors seem to point toward flywheel use as a small scale device. As such, it could be used as a storage unit for individual households to yield energy when brown-out conditions occur. It might also be used as a source of emergency power. Due to inherent mechanical simplicity, the flywheel is a reliable storage system. (Author)

**N78-30699#** California Univ., Livermore. Lawrence Livermore Lab.

**UTILIZATION OF FLYWHEELS FOR THE EVOLUTION OF HIGH-PERFORMANCE ELECTRIC VEHICLES**

L. G. O'Connell, J. F. Cooper, A. B. Miller, and H. W. Newkirk  
19 Oct 1977 16 p refs  
(Contract W-7405-eng-48)  
(UCRL-52346) Avail: NTIS HC A02/MF A01

The performance of current and future electric vehicles is examined and compared with that of projected heat engine vehicles. The shortcomings of electric vehicles in the near future are also discussed. It is predicted that the all-electric vehicle, even those utilizing flywheels to meet transient power demands, will not gain wide acceptance in the near future because of degraded performance characteristics. It is indicated that the flywheel always improves performance and range under certain circumstances. Therefore, a hybrid concept that can increase performance in the near future is examined.

**N78-27544#** Draper (Charles Stark) Lab., Inc., Cambridge, Mass.  
**RESEARCH TOWARD IMPROVED FLYWHEEL SUSPENSION AND ENERGY CONVERSION SYSTEMS**  
Final Report

David Eisenhaure Nov. 1977 181 p refs  
(Grant NSF AER-75-18813)  
(PB 278679/G; R-1108) Avail: NTIS HC A09/MF A01 CSCL 10B

Flywheel and energy conversion studies were directed toward the utilization of flywheel energy storage for utility load leveling during peak power periods, both at the residential and utility levels, for complementing windmill or photovoltaic systems, and for transportation systems. A set of system requirements which would allow two way power flow between a high speed flywheel shaft and a 60 Hz line was outlined. Existing conversion system types were studied, indicating that the system requirements could be best met with a new concept. Therefore, a special purpose integrated rotating machine and power switching stage were designed. GRA

**Development of the "Bandwrap" Flywheel.**

C. E. Knight, Jr., J. J. Kelly, R. L. Huddleston, and R. E. Pollard.

Oak Ridge Y-12 Plant, Tenn. 1977. 20p CONF-771053-3  
Y/DA-7290 Price code: PC A02/MF A01

A program for development of fiber composite flywheels and associated containment was started in May 1976 at the Oak Ridge Y-12 Plant. The development of the first test flywheel in the program is described. The flywheel design uses a thick rim element and unidirectional fiber composite bands which pass around the rim diameter and across a metal hub fitted to the drive shaft. The individual bands are meshed together at the hub and function similar to spokes on a wheel. The design is called the "Bandwrap" flywheel. The development leading to the first test flywheel is reported in the May to September 1976 Project Report. In the development process, conceptual designs were selected for detailed study. After detailed study, the Bandwrap design was selected for fabrication and test. After fabrication, the flywheel was spun to 18,000 rpm where a predicted delamination occurred in the rim. At this speed, the energy stored was 0.25 kwh and the energy density was 10.1 Wh/lb. (ERA citation 03-012499)

**FLYWHEEL ENERGY STORAGE. I. BASIC CONCEPTS.**

J.A. Kirk. p.223-31.

**FLYWHEEL ENERGY STORAGE. II. MAGNETICALLY SUSPENDED SUPERFLYWHEEL. p.233-45.**

Internat. J. Mechanical Sciences, v.19, no.4, 1977.

**N78-25592#**

**Fiber Composite Flywheel Program. Quarterly Progress Report, July--September 1977.**

J. A. Rinde.

California Univ., Livermore. Lawrence Livermore Lab. 2  
Dec 77. 8p

UCRL-50033-77-3 Price code: PC A02/MF A01

Fiber composite flywheels are planned for use in energy-storage systems because they have strength-to-density ratios, enabling them to store large amounts of kinetic energy per unit mass. Research progress is reported in the areas of stress rupture, composite properties, and composites with flexible matrices. (ERA citation 03-024107)

**N79-10555** AirResearch Mfg. Co., Torrance, Calif.  
**STUDY OF FLYWHEEL ENERGY STORAGE VOLUME 1:**  
**EXECUTIVE SUMMARY Final Technical Report**  
 L. J. Lawson, A. K. Smith, and G. D. Davis 1 Sep. 1977  
 123 p refs 5 Vol  
 (Contract DOT-UT-60097T) **6 VOLUMES**  
 (PB 282652/7; UMTA CA-06-0106-77-1-Vol-1) Avail: NTIS  
 HC A06/MF A01; also available in set of 5 reports HC E14 as  
 PB 282651-SET CSCL 13F

The practicality and viability of flywheel propulsion systems for urban mass transit vehicles was studied. The U.S. transit properties requirements show that the most suitable vehicle for deployment of flywheel propulsion is the full-size transit bus. Several propulsion concepts were hypothesized and subjected to comparative analysis with present diesel buses, trolley coaches, and battery buses in regard to performance and life-cycle economics. The following basic concepts could provide high quality transit service: pure flywheel propelled bus; flywheel/diesel engine hybrid bus; flywheel-augmented trolley coach; and flywheel/battery hybrid bus. Design studies conducted for the four propulsion configurations show a high degree of commonality of components among the four concepts. Final life-cycle cost analyses show all four concepts to be in a competitive range with present transit vehicles. **10555 THRU 10559** GRA

**N79-10663** General Electric Co., Schenectady, N. Y.  
**A STUDY OF FLYWHEEL ENERGY STORAGE FOR URBAN TRANSIT VEHICLES Final Report**  
 Sep. 1977 213 p refs  
 (Contract DOT-UT-60096T)  
 (PB 282929/9; UMTA-NY-06-0062-77-1) Avail: NTIS  
 HC A10/MF A01 CSCL 13F

The use of flywheel storage as applied to fixed-route, multistop, and rubber-tired urban transit vehicles was studied. The application of flywheel energy storage to a broad spectrum of electrically powered urban transit vehicles was also studied. Charts, tables, major conclusions and recommendations are provided. System requirements; flywheel/motor energy storage packages; life-cycle cost analysis, methodology, and worksheets; modularity in design; and a list of references are included. GRA

**ECONOMIC AND TECHNICAL FEASIBILITY STUDY FOR ENERGY STORAGE FLYWHEELS** by Rockwell International Space Division.  
 The objective of this study was to determine the technical and economic feasibility of flywheel energy storage systems for energy conservation in the residential, commercial, industrial, transportation, and utility sectors, with emphasis on utility system applications. Paperback, 425 pages.  
 P3709 \$12.50

## THE USE OF COMPOSITE FLYWHEELS FOR BRAKING ENERGY RECOVERY IN ROAD TRANSPORT VEHICLES.

R. Bennison.

Composites, v.8, no.3, July 1977, p.139-144.

Two ceramic matrix materials are evaluated for use in carbon reinforced composites. Two methods are given of coating the carbon fibres with SiC, (chemical vapour deposition and plasma activated vapour deposition), as well as the method used for impregnating the matrix materials with the coated fibres. The oxidation resistances at an elevated temperature (700°C) are investigated and compared for the two materials and the effect of oxidation on the mechanical strengths of the composite materials is studied.

78N20637# ISSUE 11 PAGE 1464 CATEGORY 44 RPT#:  
 UCRL-79154 CONF-77-430-20 CNT# W-7405-ENG-48  
 77/01/28 42 PAGES UNCLASSIFIED DOCUMENT  
 UTTL: Flywheel-battery Hybrid power system: A concept to  
 improve electric vehicle performance  
 AUTH: A/DAVIS, D. D.; B/EPPS, R. C.  
 CORP: California Univ., Livermore, Lawrence Livermore Lab.  
 AVAIL: NTIS SAP: HC A03/MF A01  
 Presented at 4th Intern. Symp. on Automotive  
 Propulsion Systems, Arlington, Va., 17-22 Apr. 1977  
 MAJS: /ELECTRIC AUTOMOBILES/FLYWHEELS/MECHANICAL  
 ENGINEERING  
 MINS: /ELECTRIC BATTERIES/MICROPROCESSORS  
 ABA: ERA  
 ABS: A high-energy composite flywheel was coupled to a  
 simple, efficient, electro-mechanical transmission.  
 Lead-acid as well as near-term and advanced battery  
 types were examined as prime power sources.  
 Interactive control of battery and/or flywheel drive  
 power was provided by a versatile microprocessor-based  
 power control unit. The flywheel augmented the battery  
 during periods of high power demand: starting,  
 acceleration, and hill climbing. With battery power  
 demand stabilized at a low value, specific energy was  
 maintained near maximum and resulted in increased  
 vehicle range. Vehicle kinetic energy was restored to  
 the flywheel when traveling downhill or during any  
 period of deceleration. The flywheel-battery hybrid  
 was thus able to make efficient use of a regenerative  
 braking system to recover energy.



77A48728 ISSUE 23 PAGE 3981 CATEGORY 44  
77/00/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Flywheel module for electric vehicle regenerative braking

AUTH: A/LUSTENADER, E. L.; B/RICHTER, E.; C/TURNBULL, F. G.; D/HICKEY, J. S.; E/CHANG, G. PAA: D/(General Electric Co., Schenectady, N.Y.); E/(ERDA, Div. of Energy Storage Systems, Washington, D.C.)

In: Intersociety Energy Conversion Engineering Conference, 12th, Washington, D.C., August 28-September 2, 1977, Proceedings, Volume 1, (A77-48701 23-44) La Grange Park, Ill., American Nuclear Society, Inc., 1977, p. 269-274.

MAJS: /\*BRAKES (FOR ARRESTING MOTION)/ \*ELECTRIC MOTOR VEHICLES/ \*FLYWHEELS/ \*STORAGE BATTERIES/ \*TRANSPORTATION ENERGY

MINS: / AC GENERATORS/ ENERGY TECHNOLOGY/ FEEDBACK CONTROL/ INDUCTION MOTORS/ MODULES/ POWER SUPPLY CIRCUITS/ SYNCHRONOUS MOTORS

ABA: (Author)

ABS: Current battery electric vehicles are limited in multi-stop-and-go driving range and accelerating capability by the lead-acid battery which cannot handle high power peaks and still maintain high energy density. A hybrid flywheel/battery system can isolate the battery from the accelerating power peaks and also recover a substantial portion of the available braking energy. This paper describes the development of a small, high speed, lightweight flywheel/a-c synchronous motor alternator sealed energy storage package coupled to a load commutated inverter power circuit. The system stores sufficient energy in the rotor of the machine for one stop-start cycle. A composite flywheel is used to store additional energy for several cycles, or enough for climbing or descending short grades.

79N10563# ISSUE 1 PAGE 75 CATEGORY 44 RPT#:  
PB-282929/9 UMTA-NY-06-0062-77-1 CNT#: DOT-UT-60036T  
77/09/00 213 PAGES UNCLASSIFIED DOCUMENT

UTTL: A study of flywheel energy storage for urban transit vehicles TLSP: Final Report

CORP: General Electric Co., Schenectady, N. Y. AVAIL NTIS  
SAP: HC A10/MF A01

ABA: GRA

ABS: The use of flywheel storage as applied to fixed-route, multistop, and rubber-tired urban transit vehicles was studied. The application of flywheel energy storage to

a broad spectrum of electrically powered urban transit vehicles was also studied. Charts, tables, major conclusions and recommendations are provided. System requirements; flywheel/motor energy storage packages; life-cycle cost analysis, methodology, and worksheets; modularity in design; and a list of references are included.

79N10559# ISSUE 1 PAGE 74 CATEGORY 44 RPT#:  
PB-282656/8 UMTA-CA-06-0106-77-5-VOL-5 CNT#:  
DOT-UT-60097T 77/09/01 5 VOLS 91 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Study of flywheel energy storage. Volume 5: Vehicle tests TLSP: Final Technical Report

AUTH: A/LAWSON, L. J.; B/SMITH, A. K.; C/DAVIS, G. D.  
CORP: A/R Research Mfg. Co., Torrance, Calif. AVAIL NTIS

SAP: HC A05/MF A01; also available in set of 5 reports HC E14 as PB-282651-SET

MAJS: /\*ENERGY STORAGE/ \*FLYWHEELS/ \*PROPULSION SYSTEM PERFORMANCE/ \*TEST VEHICLES/ \*URBAN TRANSPORTATION

MINS: / ELECTRIC HYBRID VEHICLES/ ENERGY CONSERVATION/ REGENERATION (ENGINEERING)

ABA: GRA

ABS: The major results of tests performed on a 40-foot diesel bus and a trolley coach as related to determining the practicality and viability of flywheel propulsion systems for urban mass transit vehicles are presented. Test data from the 20-vehicle M.A.N. Electrobus demonstration program in Germany are included.

77A4761 ISSUE 23 PAGE 3983 CATEGORY 44  
77/00/00 8 PAGES UNCLASSIFIED DOCUMENT

UTTL: Energy storage - An interference assembled multiring superflywheel

AUTH: A/KIRK, J. A.; B/HUNTINGTON, R. A. PAA:  
B/(Maryland, University, College Park, Md.)  
In: Intersociety Energy Conversion Engineering Conference, 12th, Washington, D.C., August 28-September 2, 1977, Proceedings, Volume 1, (A77-48701 23-44) La Grange Park, Ill., American Nuclear Society, Inc., 1977, p. 517-524.

MAJS: /\*COMPOSITE MATERIALS/ \*ENERGY STORAGE/ \*FLYWHEELS/ \*RING STRUCTURES/ \*STRESS CONCENTRATION

MINS: / CENTRIFUGAL FORCE/ ENERGY TECHNOLOGY/ PERFORMANCE PREDICTION/ ROTOR SPEED/ STRESS ANALYSIS

ABA: (Author)

ABS: A stress analysis and energy density maximization procedure has been developed for improving the performance of multiring composite material flywheels. The procedure utilizes interference assembly between individual flywheel rings and causes a redistribution of centrifugal stresses. An example of a multiring magnetically suspended flywheel is considered and significant gains in rotor performance are shown to be possible.



78N30699# ISSUE 21 PAGE 2811 CATEGORY 44 RPT#:  
UCRL-52346 CMT# W-7405-ENG-48 77/10/19 16 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Utilization of flywheels for the evolution of high-performance electric vehicles

AUTH: A/O'CONNELL, L. G.; B/COOPER, J. F.; C/MILLER, A. B.; D/NEWKIRK, H. W.

CORP: California Univ., Livermore, Lawrence Livermore Lab.  
AVAIL: NTIS SAP: HC A02/MF A01

MAJS: /\*ELECTRIC PROPULSION/\*FLYWHEELS

MINS: / AUTOMOBILE ENGINES/ ENERGY CONSERVATION/ PERFORMANCE TESTS

ABA: ERA

ABS: The performance of current and future electric vehicles is examined and compared with that of projected heat engine vehicles. The shortcomings of electric vehicles in the near future are also discussed. It is predicted that the all-electric vehicle, even those utilizing flywheels to meet transient power demands, will not gain wide acceptance in the near future because of degraded performance characteristics. It is indicated that the flywheel always improves performance and range under certain circumstances. Therefore, a hybrid concept that can increase performance in the near future is examined. This type of vehicle is a much-needed transition system to provide an evolutionary change from the heat engine vehicle of today to future electric vehicles with acceptable performance.

77A39314 ISSUE 18 PAGE 3065 CATEGORY 44  
77/00/00 9 PAGES UNCLASSIFIED DOCUMENT

UTTL: Flywheel energy storage. I - Basic concepts

AUTH: A/KIRK, J. A. PAA: A/(Maryland, University, College Park, Md.)  
International Journal of Mechanical Sciences, vol. 19, no. 4, 1977, p. 223-231

MAJS: /\*ELECTRIC GENERATORS/\*ENERGY STORAGE/\*FLYWHEELS/\*ROTATING DISKS

MINS: / BLOCK DIAGRAMS/ COUNTER-ROTATING WHEELS/ DESIGN ANALYSIS/ ENERGY DISSIPATION/ ENERGY TECHNOLOGY/ EQUILIBRIUM EQUATIONS/ FLUX DENSITY

ABA: (Author)

ABS: The basic concepts of flywheel energy storage systems are described in the first part of a two part paper. General equations for the charging and discharging characteristics of flywheel systems are developed and energy density formulas for flywheel rotors are discussed. It is shown that a suspended pierced disk flywheel is competitive with the super-flywheel designs currently being suggested in the literature.

77A23900 ISSUE 9 PAGE 1441 CATEGORY 44  
77/02/00 6 PAGES In GERMAN UNCLASSIFIED DOCUMENT

UTTL: Hybrid propulsion system for motor vehicles with predominantly intermittent mode of operation

AUTH: A/BARTSCH, H. J.; B/HELLING, J.; C/SCHRECK, H. PAA: C/(Rheinisch-Westfaelische Technische Hochschule, Aachen, West Germany)  
VDI-Z, vol. 119, no. 3, Feb. 1977, p. 141-146. In German.

MAJS: /\*ENERGY STORAGE/\*ENGINE DESIGN/\*FLYWHEELS/\*FUEL CONSUMPTION/\*HYBRID PROPULSION/\*MOTOR VEHICLES

MINS: / COMBUSTION CHAMBERS/ DECOUPLING/ ELECTRIC GENERATORS / INTERMITTENCY/ OPERATIONS RESEARCH/ POLLUTION

CONTROL/ STORAGE BATTERIES/ URBAN TRANSPORTATION

ABA: G.R.

ABS: In the case of motor vehicles used in city traffic or in other traffic situations involving an intermittent mode of operation, fuel can be saved by making use of an energy storage device. A flywheel system can be employed as such an energy storage device. A theoretical investigation is conducted concerning the operational characteristics of a suitable flywheel system for motor vehicle applications and the energy which can be saved with the aid of such a system. The practical implementation of the considered concepts is discussed and the operational characteristics of vehicles with conventional and with hybrid propulsion systems are compared.

FIBER GLASS FOR COMPOSITE FLYWHEELS  
S. N. Loud

SAMPE Journal

Vol 13, No. 3 May/June 1977  
p. 20-22

Composite materials offer the most cost-effective approach to inertial energy storage systems utilizing flywheels, for electrical energy storage in utilities, military applications and transportation. Fiber glass reinforced plastics (FRP) should be considered as one of the most likely material system choices, because of proven and projected performance capabilities and because of their low cost potential.

77A39315\* ISSUE 18 PAGE 3065 CATEGORY 44  
 77/00/00 13 PAGES UNCLASSIFIED DOCUMENT  
 UTTL: Flywheel energy storage. II - Magnetically suspended  
 super-flywheel  
 AUTH: A/KIRK, J. A.; B/STUDER, P. A. PAA: A/(Maryland,  
 University, College Park, Md.); B/(NASA, Goddard  
 Space Flight Center, Electromechanical Branch,  
 Greenbelt, Md.)  
 CORP: Maryland Univ., College Park.; National Aeronautics  
 and Space Administration, Goddard Space Flight Center,  
 Greenbelt, Md.  
 International Journal of Mechanical Sciences, vol. 19,  
 no. 4, 1977, p. 253-245.  
 MAJS: /-ENERGY CONVERSION EFFICIENCY/-ENERGY STORAGE/  
 FLYWHEELS/MAGNETIC SUSPENSION/-ROTOR SPEED  
 MINS: / COMPOSITE MATERIALS/ ELECTRIC GENERATORS/ ENERGY  
 TECHNOLOGY  
 ADA: (Author)  
 ABS: This article, the second of a two part paper,  
 describes the general design requirements for a  
 flywheel energy storage system. A new super-flywheel  
 energy storage system, using a spokeless, magnetically  
 suspended, composite material pierced disk rotor is  
 proposed. The new system is configured around a  
 permanent magnet ('flux biased') magnetic suspension  
 system with active control in the radial direction and  
 passive control in the axial direction. The storage  
 ring is used as a moving rotor and electronic  
 commutation of stationary armature coils is proposed.  
 There is no mechanical contact with the rotating ring  
 and long life and low run down losses are projected. A  
 discussion of major components for a 10 kwh system is  
 presented.

**N78-30695#** Oak Ridge Y-12 Plant, Tenn.  
**DEVELOPMENT OF THE BANDWRAP FLYWHEEL**  
 C. E. Knight, Jr., J. J. Kelly, R. L. Huddleston, and R. E. Pollard  
 1977 20 p refs Presented at the Flywheel Technol. Symp.,  
 San Francisco, 5-7 Oct. 1977  
 (Contract W-7405-eng-26)  
 (Y/DA-7290; Conf-771053-3) Avail: NTIS HC A02/MF A01

The development of the first test flywheel is described. The  
 flywheel design uses a thick rim element and unidirectional fiber  
 composite bands which pass around the rim diameter and across  
 a metal hub fitted to the drive shaft. The individual bands are  
 meshed together at the hub and function similar to spokes on a  
 wheel. The design is called the 'bandwrap' flywheel. In the  
 development process, conceptual designs were selected for  
 detailed study. After detailed study, the bandwrap design was  
 selected for fabrication and test. After fabrication, the flywheel  
 was spun to 18,000 rpm where where a predicted delamination  
 occurred in the rim. At this speed, the energy stored was 0.25 kwh  
 and the energy density was 10.1 Wh/lb. ERA

**D. C.**  
**ENERGY CONSERVATION STANDARDS FOR BUILDINGS:**  
**STATUS OF STATES' REGULATORY ACTIVITIES**  
 15 Feb. 1978 32 p  
 (Contract HUD-H-2822-RG)  
 (PB-279936/9; HUD/RES-1331) Avail: NTIS  
 HC A03/MF A01 CSCL 10A

A directory of the state executive offices with responsibility  
 for energy conservation and buildings standards under the divisions  
 of: (1) energy policy; (2) Standards Administration; (3) Standards  
 Enforcement; and (4) Building Codes and Standards is reported.  
 GRA

**N78-30710#** Environmental Law Inst., Washington, D. C.  
**LEGAL AND INSTITUTIONAL PERSPECTIVES ON SOLAR**  
**ENERGY IN COLORADO. A CASE STUDY OF LAND USE**  
**AND ENERGY DECISION-MAKING** Final Report  
 Karin H. Hillhouse, Ellen E. Kohler, Richard A. Liroff, and Alan

## Flywheels

TA418.9

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1977

V.22

p.442 -

**N78-10587#** California Univ., Livermore. Lawrence Livermore  
 Lab

**FIBER-COMPOSITE SYSTEMS FOR ENERGY-STORAGE**  
**FLYWHEELS**

L. S. Penn and E. S. Jessop 31 Dec. 1976 13 p refs Presented  
 at the 22nd Natl. SAMPE Symp./Exhibition, San Diego, Calif.  
 26-28 Apr. 1977  
 (Contract W-7405-eng-48)  
 (UCRL-78610; Conf-770407-2) Avail: NTIS  
 HC A02/MF A01

Fiber-composite systems for use in energy-storage flywheels  
 (Kevlar 49/epoxy, Kevlar 29/epoxy, S2-glass/epoxy, and  
 E-glass/epoxy) were studied. The performances of the four  
 materials were compared and a relationship between results of  
 conventional materials tests and spin tests was obtained. For  
 each material, tensile tests of epoxy-coated strands, hydroburst  
 tests of NOL rings, and hydroburst and spin tests of thin-rim  
 composite rotors about 406 mm in diameter were performed.  
 The results of the rotor and NOL ring hydroburst tests were the  
 same as the results of the spin tests. For the thin-rim rotor  
 design, hydroburst tests of the rotor or of the NOL ring can be  
 used to predict spin performance. In terms of energy density,  
 Kevlar 49/epoxy ranked highest, but in terms of energy density  
 per unit cost, E-glass/epoxy was best. ERA

(UCRL--79503) Bibliographic and numeric data bases for fiber composites and matrix materials. McMurphy, F.E.; Quick, T.M. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 30 Sep 1977. Contract W-7405-ENG-48. 9p. (CONF-771053--2). Dep. NTIS, PC A02/MF A01.

From Flywheel technology symposium, San Francisco, California, USA (5 Oct 1977).

Research leading to the creation of bibliographic and numeric data bases of material properties, under contract with ERDA's Division of Energy Storage Systems, (ERDA/STOR) is reported. Both bibliographic and numeric data bases for fiber composites and matrix materials, with particular emphasis to their application to modern flywheel technology have been created. The bibliographic data base was created to provide a direct means to visually examine pertinent literature. The numeric data base is being created to provide evaluated materials properties data for direct input to applications programs. These and related data bases are being prepared to serve ERDA/STOR administrators and their contractors in the expanding field of energy storage. Data bases and their evaluation programs will be stored on a PDP-11/70 computer system at LLL and be available for interactive use over the ARPAnet and by telephone dialup.

HT Pittsburgh Conference on Modeling and Simulation,  
166 8th, University of Pittsburgh, 1977.  
.P5 Modeling and simulation ... c1977. (Conf-2)  
1977 Held April 21-22, 1977. University of  
SIMULATION STUDY OF A FLYWHEEL POWERED ELECTRIC VEHICLE UTILIZING THE MODERN  
HIGH ENERGY DENSITY ENERGY STORAGE FLYWHEEL, David R. Markus and Ronald Krutz,  
Carnegie-Mellon University. P.287

Modern inertial energy storage devices offer attractive possibilities as a power source in electric vehicles. To demonstrate this, a flywheel powered electric vehicle is designed and simulated in detail. Simulation is carried out subject to the characteristics of commercially available equipment; where actual device characteristic curves are used whenever possible. Hence, the effects of component nonlinearities and variable efficiencies as well as system constraints are included. Based upon this approach, vehicle performance may be evaluated in greater breadth and depth than traditionally done.

77N21685# ISSUE 12 PAGE 1623 CATEGORY 44 RPT#:  
ERDA-76-65 SD-75-SA-0166 CNT# E104-31-1000  
75/12/00 421 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Economic and technical feasibility study for energy  
storage flywheels TISP: Final Report  
CORP: Rockwell International Corp., Downey, Calif. CSS: (Space Div.) AVAIL:NTIS SAP: HC A18/MF A01  
MAJS: /ENERGY STORAGE/FLYWHEELS/SYSTEMS ENGINEERING  
MINS: /HEATING/ INDUSTRIES/ RESIDENTIAL AREAS/  
TRANSPORTATION  
ABA: ERA  
ABS: Flywheel energy storage systems (FESS) for energy conservation in the residential, commercial, industrial, transportation, and utility sectors were studied. Emphasis was placed on utility system applications. Results of the study show that FESS are technically feasible for all sectors examined. It was established that the cost of energy storage is the more important factor in the feasibility of FESS applications.

# Composite Flywheel Development, May 1--June 30, 1976.

R. L. Huddleston, J. J. Kelly, and C. E. Knight.

Oak Ridge Y-12 Plant, Tenn. Jan 77, 26p

Y-2072 Price code: PC A03/MF A01

A report is given summarizing Union Carbide Corporation-Nuclear Division's (UCC-ND's) composite flywheel program objectives and accomplishments for the period from May 1 through June 30, 1976. The necessity and urgency of national energy conservation is a well-recognized fact. Mechanical-energy storage, using rotating flywheels, is one of the few known methods for energy storage, and flywheels probably have the highest potential effectiveness for energy storage of any method now available. Initial application selected for the development of the composite flywheel is the heat engine/flywheel hybrid propulsion system for a vehicle, because of its high potential for the conservation of petroleum fuel in both the near and long-range time frames. Efforts have focused into key areas consistent with its experience base: state-of-the-art flywheel development, spin testing, and containment development. An operating performance goal of 20 watt-hr/lb (20 Wh/lb) energy density at an energy level of 0.56 kWh has been set by UCC-ND. The 20 Wh/lb goal encompasses both the composite flywheel and the hub that connects it to the shaft. It does not include the shaft. The goal exceeds the present performance of isotropic flywheels, and is also at the upper limit of current laboratory technology reported in the literature for composite flywheels. The thick rim with radial overwrap bands was selected as the initial design concept. Kevlar-49/epoxy was selected as the construction material, and the end of the design phase is near. A process for fabricating full-scale Kevlar-49/epoxy thick rims was developed, and full-scale rims were successfully wound. More detailed information



77N19622# ISSUE 10 PAGE 1340 CATEGORY 44 EPT#  
UCID 17098-VOL-1 CNT# W-7105-ENG-48 76/04/15 3  
VOLS 52 PAGES UNCLASSIFIED DOCUMENT

UTTL: Battery-flywheel hybrid electric power system for  
near-term application. Volume 1: System description  
AUTH: A/DAVIS, D. D.; B/O'CONNELL, L. G.; C/WARNER, S. E.;  
D/RAYNARD, A. E.; E/HOWLETT, B. H.  
CORP: California Univ., Livermore. Lawrence Livermore Lab.  
AVAIL NTIS SAP: HC A04/MF A01  
MAJS: /\*ELECTRIC BATTERIES/\*ELECTRIC POWER SUPPLIES/\*  
FLYWHEELS/\*HYBRID PROPULSION  
MINS: / ELECTRIC CELLS/ KINETIC ENERGY/ PROPULSION SYSTEM  
PERFORMANCE/ SYSTEMS ANALYSIS

ABA: ERA

ABS: A description is given of a hybrid propulsion system  
design, based upon demonstrated technology, that  
substantially improves performance, range, and  
consumer acceptability of a battery-powered electric  
vehicle. A newly demonstrated high energy composite  
flywheel is coupled to an extremely simple, efficient,  
electro-mechanical transmission. Lead acid batteries  
provide the prime power source. Interactive control of  
battery and flywheel drive power is provided by a  
versatile microprocessor-based power control unit.  
Efficient recovery of vehicle kinetic energy during  
braking, plus the energy base required to meet all  
high power transient demands, is provided by the  
flywheel. Battery demand is stabilized at a low  
average value resulting in improved battery  
performance through increases in both cycle life and  
available energy. Electric vehicle acceleration and  
range improvements due to the hybrid system described  
are predicted to be in excess of 80 percent for a  
vehicle operated in a stop-and-go commuter  
environment.

N77-29616# California Univ., Livermore. Lawrence Livermore  
Lab.

**OPTIMAL DESIGN OF ANISOTROPIC (FIBER-  
REINFORCED) FLYWHEELS**

R. M. Christensen and E. M. Wu 2 Nov. 1976 16 p refs  
(Contract W-7405-eng-48)

(UCRL-52169) Avail: NTIS HC A02/MF A01

An analysis is given of the kinetic energy storage capacity  
of anisotropic flywheels. Using a uniform strain failure criteria,  
the optimal shapes of flywheels are determined as a function of  
the degree of anisotropy. Within this spectrum of shapes, practical  
design considerations are shown to favor the case where there  
is equal reinforcement in the radial and circumferential directions.  
Comparisons are made between the present solid-wheel-type  
design and the ring design and also between candidate materi-  
als. ERA

77A12664 ISSUE 2 PAGE 231 CATEGORY 44 CNT#  
DOT-05-30112 76/00/00 8 PAGES UNCLASSIFIED  
DOCUMENT

UTTL: The fuel efficiency potential of a flywheel hybrid  
vehicle for urban driving  
AUTH: A/FRANK, A. A.; B/BEACHLEY, N. H.; C/HAUSENBAUER, T.  
C.; D/TING, P. PAA: D/(Wisconsin, University,  
Madison, Wis.)

In: Intersociety Energy Conversion Engineering  
Conference, 11th, State Line, Nev., September 12-17,  
1976. Proceedings, Volume 1. (A77-12662 02-44) New  
York, American Institute of Chemical Engineers, 1976.  
p. 17-24. U.S. Department of Transportation

MAJS: /\*AUTOMOBILES/\*ENERGY TECHNOLOGY/\*FLYWHEELS/\*URBAN  
TRANSPORTATION

MINS: / ENERGY STORAGE/ ENGINE DESIGN/ FUEL CONSUMPTION/  
INTERNAL COMBUSTION ENGINES/ TRANSMISSIONS (MACHINE  
ELEMENTS)

ABA: (Author)

ABS: The concept of a flywheel energy management power  
plant (FEMP) for automobiles, consisting of an  
internal combustion engine, an energy-storage  
flywheel, and a continuously-variable transmission  
(CVT), has been found to have the potential of greatly  
increasing fuel economy in urban driving. The  
improvement occurs because of two factors: (1) The  
engine is only run at or near its highest efficiency,  
and (2) the system allows efficient regenerative  
braking. The design details of an experimental  
flywheel vehicle currently under construction are  
discussed. This vehicle is projected by a complete  
simulation to achieve a 58% improvement in fuel  
economy over the EPA-CVS city driving cycle, with  
further research and development, however, it is felt  
that a 100% improvement is feasible. The flywheel  
concept has been found very sensitive to component  
efficiencies, with the CVT being the most critical  
item in this regard.

**N77-31620# General Electric Co., Schenectady, N.Y.  
DEMONSTRATION OF AN INDUCTOR MOTOR/  
ALTERNATOR/FLYWHEEL ENERGY STORAGE SYSTEM  
Quarterly Progress Report, 28 Jun. - 28 Sep. 1976**

28 Sep. 1976 52 p

(Contract EY-76-C-02-4010)

(COO-4010-1; PR-1) Avail: NTIS HC A04/MF A01

Vehicle propulsion concepts utilizing flywheel energy are  
described. Analyses are presented for sizing an inductor  
motor/alternator/flywheel for application to a 3000 pound vehicle.  
Component tradeoffs are included for the inductor motor/  
alternator drive, the solid state inverter/rectifier, the control circuit,  
and a composite flywheel. Design specifications for the machine  
are established and a test plan defined. ERA



77A10638 ISSUE 1 PAGE 71 CATEGORY 44 76/10/00  
2 PAGES UNCLASSIFIED DOCUMENT

UTTL: Super flywheel energy storage and nonsynchronous AC/DC/AC electric transmission supplements power system operation  
AUTH: A/REITAN, D. K.; B/BAHARI-KASHANI, M. PAA: B/(Wisconsin, University, Madison, Wis.)  
IEEE, Proceedings, vol. 64, Oct. 1976, p. 1543, 1544.  
MAJS: /\*ELECTRIC POWER SUPPLIES/\*ENERGY CONVERSION EFFICIENCY/\*ENERGY STORAGE/\*FLYWHEELS/\*KINETIC ENERGY  
MINS: / ALTERNATING CURRENT/ DIRECT CURRENT/ ENERGY TRANSFER / FREQUENCY CONVERTERS/ SPEED CONTROL/ VOLTAGE CONVERTERS (AC TO AC)/ WAVEFORMS  
ABA: G.R.  
ABS: The design and the operation of flywheels for energy storage applications are considered, taking into account the use of such devices in utility networks. During an off-peak period energy is stored in the flywheel. The kinetic energy in the flywheel can be converted into electrical energy when additional power is needed. Attention is given to the characteristics of the electrical system required for a suitable energy conversion.

77A11040 ISSUE 1 PAGE 73 CATEGORY 44 76/06/00  
12 PAGES UNCLASSIFIED DOCUMENT

UTTL: Energy storage --- quality, duration, methods and forms  
AUTH: A/SMITH, I. E. PAA: A/(Cranfield Institute of Technology, Cranfield, Beds., England)  
In: Aspects of energy conversion: Proceedings of the Summer School, Oxford, England, July 14-25, 1975. (A77-11026 01-44) Oxford, Pergamon Press, 1976, p. 507-518.  
MAJS: /\*ENERGY STORAGE/\*ENERGY TECHNOLOGY/\*KINETIC ENERGY  
MINS: / CHEMICAL ENERGY/ ENERGY DISSIPATION/ ENTROPY/ FLYWHEELS/ HEAT STORAGE/ SPECIFIC HEAT/ STORAGE STABILITY/ TIME DEPENDENCE  
ABA: G.R.  
ABS: Questions concerning the quality of storage are considered along with aspects of storage duration and the storage scale. A description is presented of the methods of energy storage, taking into account chemical energy, sensible heat storage, latent heat storage, and the heat of solution and reverse osmosis. An investigation is conducted regarding the most suitable forms of kinetic energy storage. A table listing materials of construction for flywheels is presented. Attention is also given to problems related to the occurrence of energy storage losses.

77A15856 ISSUE 4 PAGE 562 CATEGORY 44 76/11/00  
3 PAGES In GERMAN UNCLASSIFIED DOCUMENT

UTTL: High-speed flywheels as possible energy storage devices in the future  
AUTH: A/GAEDKE, M. PAA: A/(Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Institut fuer Strukturmechanik, Braunschweig, West Germany)  
DFVLR-Nachrichten, Nov. 1976, p. 778-780. In German.  
MAJS: /\*COMPOSITE STRUCTURES/\*ENERGY STORAGE/\*FLYWHEELS/\*HIGH SPEED  
MINS: / AROMATIC COMPOUNDS/ CARBON FIBER REINFORCED PLASTICS / ENERGY CONVERSION/ ENERGY TECHNOLOGY/ GLASS FIBER REINFORCED PLASTICS/ LAMINATES/ SOLAR ENERGY/ STORAGE BATTERIES/ TECHNOLOGICAL FORECASTING/ TIME DEPENDENCE/ WINDPOWERED GENERATORS  
ABA: R.D.V.  
ABS: The usefulness of flywheels as energy-storage devices in various energy-consuming or energy-converting systems is assessed. Some composite flywheels (glass fiber reinforcement, carbon fiber reinforcement, kevlar fiber) are found to have four times the strength of steel in flywheel applications. Coupling of flywheels with motor-generator sets, batteries, or power grids for storage and return of power is discussed (with helium or hydrogen atmospheres to minimize winding friction in motor-generator sets). Use of flywheels for energy storage in energy conversion systems with irregular energy inputs (solar energy, wind energy) is considered. Tests on existing prototypes of composite flywheels are reported, and coiling of flywheel fiber-reinforced laminates is described.

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1976  
Intersociety Conference on Transportation,  
4th, Los Angeles, 1976.  
Proceedings / Fourth Annual Intersociety  
Conference on Transportation, July 19-23,  
1976, Los Angeles, California. -- New York :  
American Society of Mechanical Engineers,  
c1976.

649 p. in various pagings : ill. ; 29 cm.  
Includes bibliographical references.  
Modeling of Electric Drive Systems for KEW . I. American  
(Flywheel) Vehicles  
Alexander Kusko, Frank Raposa,  
Charles King, and Clement Somuah  
E&F-2

✓ 77N12536# ISSUE 3 PAGE 356 CATEGORY 44 RPT#:  
PB-256117/3 DOT-151-76-57-2 CNT# : DOT-OS-30112  
75/12/00 22 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Increased fuel economy in transportation systems by  
use of energy management: Second year's program.  
Executive summary TLSP: Final Report  
AUTH: A/BEACHLEY, N. H.; B/FRANK, A. A.  
CORP: Wisconsin Univ., Madison. CSS: (Engineering  
Experiment Station.) AVAIL.NTIS SAP: HC A02/MF  
A01  
MAJS: /\*AUTOMOBILE ENGINES/\*FLYWHEELS/\*FUEL CONSUMPTION/\*  
MECHANICAL DRIVES  
MINS: / ENERGY CONSUMPTION/ EXHAUST GASES/ TRANSPORTATION  
ENERGY  
ABA: GRA

ABS: Design and analytic evaluation of experimental  
vehicles equipped with a flywheel energy management  
powerplant (FEMP) are covered. Development of modeling  
techniques that permit the accurate prediction of  
transient emissions from an automobile over any  
driving cycle are discussed. A limited investigation  
of the fuel-saving potential of relatively  
straightforward changes to transmissions and  
drivetrain systems is included.

✓ 78N13579# ISSUE 4 PAGE 502 CATEGORY 44 RPT#:  
COO-4010-2 TQPR-2 CNT# : EY-76-C-02-4010 76/12/28  
36 PAGES UNCLASSIFIED DOCUMENT  
UTTL: Demonstration of an inductor motor/alternator/flywheel  
energy storage system TLSP: Technical Quarterly  
Progress Report, 28 Sep. - 29 Dec. 1976  
CORP: General Electric Co., Schenectady, N. Y. CS: (  
Corporate Research and Development Div.) AVAIL.NTIS  
SAP: HC A03/MF A01  
MAJS: /\*AC GENERATORS/\*ENERGY STORAGE/\*FLYWHEELS/\*INDUCTION  
MOTORS/\*SYSTEMS ENGINEERING  
MINS: / DESIGN ANALYSIS/ ELECTRIC BATTERIES/ MANUFACTURING  
ABA: ERA

ABS: The concept, consisting of a high-speed composite  
flywheel combined with an integral inductor-type  
motor/alternator, offers the possibility of a small,  
lightweight package with high energy storage  
capability. The basic technology demonstrated in this  
program have application to a number of flywheel  
energy storage systems. The demonstration unit has a  
nominal rating of 20 kVA. The program will develop a  
flywheel energy storage system sized for a 3000 lb  
battery electric van. The design and fabrication of  
the inductor motor/alternator/flywheel; and design and  
fabrication of the solid state power conditioner and  
control breadboard are discussed.

**N77-29602** Purdue Univ., Lafayette, Ind.  
**APPLICATIONS OF A DOUBLY-FED INDUCTION MACHINE  
IN A LARGE FLYWHEEL ENERGY STORAGE SYSTEM**  
Ph.D. Thesis

Kongkun Hemmaplardh 1976 115 p  
Avail: Univ. Microfilms Order No. 77-7466

A doubly-fed induction machine is analyzed. The power  
and torque expressions are obtained. By introducing a change  
in the machine parameter, the possibility of constant power  
operation of the machine over a wide speed range is estab-  
lished. Steady state stability of the machine is investigated. Steady  
state operation of the machine over a wide speed range with  
no additional control involves a region of instability.

Dissert. Abstr.

TA Institute of Environmental Sciences.  
1 Technical division proceedings including  
.I39813 career guidance forum notes. Mt. Prospect,  
1975 Ill., IES [1975]  
v.1 xx, 184 p. illus. 28 cm.  
"21st annual  
Calif., April :  
Vol. 2 of 2  
Energy and the



3 1176 00044 7186

THE KINETIC ENERGY WHEEL: A MEANS OF REDUCING POLLUTION WHILE  
By L. J. Lawson . . . . . P130 . . . . .  
201 71 12-A-X

CONSERVING RESOURCES  
.....

TA Society of Engineering Science.  
5 Proceedings of the 12th annual meeting...  
.S63 c1975. (Card 2)  
1975  
Office of Naval Research. II. Southwest  
Research Institute.

"Thermal Stresses in Composite Flywheels," by R. C. Reuter, Jr.

#29

79N72975\* CATEGORY 44 RPT#: NASA-CR-114208  
TM-70-1012-3 CNT#: NASW-417 70/09/15 16 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Solar cell, flywheel energy storage power system  
UNOC: Characteristics of solar cell-flywheel energy storage  
power system  
AUTH: A/GORMAN, R.

CORP: Bellcomm, Inc., Washington, D. C.  
MAJS: /\*ENERGY STORAGE/\*FLYWHEELS/\*SOLAR CELLS  
MINS: / EQUIPMENT SPECIFICATIONS/ SPACECRAFT POWER SUPPLIES/  
SYSTEMS ENGINEERING

79N72970\* CATEGORY 44 RPT#: NASA-CR-110277  
B71-06022 CNT#: NASW-417 71/06/18 20 PAGES  
UNCLASSIFIED DOCUMENT

UTTL: Flywheel energy storage for the space shuttle  
auxiliary power unit

AUTH: A/GORMAN, R.  
CORP: Bellcomm, Inc., Washington, D. C.  
MAJS: /\*AUXILIARY POWER SOURCES/\*ENERGY STORAGE/\*FLYWHEELS/\*  
SPACE SHUTTLES  
MINS: / COMBUSTION CHAMBERS/ HIGH PRESSURE/ HIGH TEMPERATURE  
/ LIQUID HYDROGEN/ TURBINES

## ENERGY STORAGE - MAGNETIC

**N80-14535#** Los Alamos Scientific Lab., N. Mex.  
**SUPERCONDUCTING MAGNETIC ENERGY STORAGE FOR  
 ELECTRIC POWER SYSTEM DYNAMIC STABILIZATION**  
 Robert Turner 1979 7 p refs Presented at Intersoc. Energy  
 Conversion Conf., Boston, 5 Aug. 1979  
 (Contract W-7405-eng-36)  
 (LA-UR-79-1220; CONF-790803-07) Avail: NTIS  
 HC A02/MF A01

A superconducting magnetic energy storage (SMES) system developed for a dynamic stabilizer to be installed in the Bonneville Power Administration (BPA) power system at Tacoma, Washington, by 1982 is described. This unit is an alternate stabilization method to the dc modulator now used to stabilize the 900 mile, ac intertie between BPA and Southern California. The SMES unit consists of a 30 MJ solenoid, a 10 MW converter, a liquid helium dewar and auxiliary systems. The SMS dynamic stabilizer design is presented with status information about the superconducting coil, the converter, and other components of the SMES dynamic stabilizer summarized. DOE

TP Applications of cryogenic technology. v. 7  
 480 ...c1978 (Card 2)  
 .A6 ISBN 0-87936-609-7  
 v.7 1. Low temperature engineering--Addresses,  
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**Microprocessor Control of AC/DC/AC Power Converters for Superconduction Magnetic Energy Storage Units . . . . 132**

J.H. Davis and John S. Fulton  
 Department of Electrical and Computer Engineering  
 New Mexico State University, Las Cruces, NM

One of the new methods of energy storage is the superconducting magnetic energy storage unit (SMES). This device promises to aid in providing both short and long term energy storage capability for electric utilities. The primary topic to be discussed in this paper is a microcomputer control system for the SCR power converter which serves as the interface between the SMES unit and a conventional AC power system.

A real-time control system has been developed to provide data logging and control of the SMES power converter. This program is based on the INTEL 8080 microcomputer system developed at Los Alamos Scientific Laboratory. It is believed this work will provide additional insight to those interested in applying microcomputers to other real-time control problems.

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